

Frederickton to Eungai

2017 Annual Ecological Monitoring Report

Roads and Maritime Services | March 2018



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Introduction

Purpose

This report provides an update on the ecological issues associated with the Frederickton to Eungai Pacific Highway upgrade. This report covers the period of 1 December 2016 to 30 November 2017. This report has been prepared in accordance with the Ecological Monitoring Program: Frederickton to Eungai (Roads and Maritime 2016), for submission to the Department of Planning and Environment and Environment Protection Authority (EPA). This report includes *Maundia triglochinos*, Hairy Joint Grass, Glossy Black Cockatoo, Brush-tailed Phascogale, Green-thighed Frog, aerial crossing, nest box, fauna underpass, and road kill monitoring undertaken in 2017.

Statutory and planning framework

Approval for the Kempsey to Eungai Pacific Highway upgrade was granted by the State Government on 10 July 2008. Kempsey to Eungai Pacific Highway upgrade is being delivered in two stages with Stage One extending from Kempsey to Frederickton and Stage Two extending from Frederickton to Eungai. This report focuses on ecological monitoring associated with Stage Two, known as the Frederickton to Eungai project.

The Kempsey to Eungai Pacific Highway upgrade approval included the requirement to develop an ecological monitoring program:

*Prior to the commencement of construction, the Proponent shall develop and implement a Monitoring Program to target the effectiveness of the mitigation measures identified in Condition 2.10(d) for the listed threatened species directly impacted by the project. The program shall include (but not necessarily be limited to) the monitoring of *Maundia triglochinos*, Green-thighed Frog, Glossy Black Cockatoo and the Brush-tailed Phascogale. The Program shall be developed in consultation with the DECCW and suitably qualified ecologist(s) and shall include but not necessarily be limited to:*

- a) the monitoring of threatened species in and adjacent to the project footprint. The methodology shall be decided in consultation with DECCW;*
- b) an adaptive monitoring program to assess the effectiveness of the mitigation measures identified in Condition 2.10 (d) and allow their modification if necessary. The monitoring program shall include targets against which effectiveness will be measured;*
- c) monitoring shall be undertaken during construction (for construction-related impacts) and from opening of the project to traffic (for operation/ongoing impacts) until such time as the effectiveness of mitigation measures can be demonstrated to have been achieved over a minimum of three successive monitoring periods, or as otherwise agreed by the Director General in consultation with DECCW;*
- d) provision for the assessment of the data to identify changes to habitat usage and if this can be attributed to the project;*
- e) details of the contingency measures that would be implemented in the event of changes to habitat usage patterns directly attributable to the construction or operation of the project; and*
- f) provision for annual reporting of monitoring results to the Director General and the DECCW, or as otherwise agreed by those agencies.*

The Program shall be submitted to the Director General prior to the commencement of construction and shall be updated to incorporate the monitoring methodology for threatened species, once agreed to, in accordance with condition of this approval.

The initial Ecological Monitoring Program: Frederickton to Eungai was approved by the Department of Planning and Environment on 25 July 2013. This was updated in 2016 and approved by the Department of Planning & Environment on 30 June 2016.

The ecological monitoring program includes the provision for annual reporting to the Director General and EPA.

Appendix A Hairy Joint Grass



Hairy Joint Grass Monitoring 2016/2017

Frederickton to Eungai Pacific Highway Upgrade

Prepared for Roads and Maritime Services

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Cover photograph: Hairy Joint Grass quadrat, impact plot 2HW. Niche Environment and Heritage, autumn 2017.

Executive Summary

Context

This report documents the third of five monitoring events for Hairy Joint Grass *Arthraxon hispidus* (HJG), as required by the Frederickton to Eungai (F2E) Ecological Monitoring Program (EMP, RMS 2016).

Aims

The aims of this report are to summarise the methods and results of the 2016/2017 monitoring, provide an overall discussion of all monitoring events and determine if performance measures have been met, as per the EMP (RMS 2016).

Methods

Hairy Joint Grass populations are known to occur at two locations within the project corridor. In accordance with the EMP these populations were monitored at four sites, including three potential impact sites and one control site.

Key results

During the 2016/2017 monitoring period Hairy Joint Grass was recorded at three of the four sites; two impact sites (1HE and 2HW), and at the control site (3CN), and flowering/seeding and recruitment was observed at one site only (impact site 2HW). The species remained absent from impact site 3HN. A substantial decrease in Hairy Joint Grass records, flowering/seeding and recruitment over successive monitoring events was found for site 2HW.

Conclusions

The performance measures of success relating to flowering/seeding between monitoring events has been met for impact sites 1HE and 3HN but was not met for impact site 2HW. The performance measure of unsuccessful mitigation relating to flowering/seeding, extent and recruitment over successive monitoring events has not been met for impact sites 1HE and 3HN but has been met for impact site 2HW.

Management implications

In order to maintain HJG populations at the sites and mitigate further decline in the HJG population at site 2HW, the following management recommendations should be considered at the impact plots:

- Careful bush regeneration activities at the impact plots and area immediately surrounding. In particular, weed management should entail careful hand weeding of introduced grasses (e.g. *Andropogon virginicus*, *Senecio madagascariensis* etc.).
- Slashing, preferably in winter (June – August). This may provide recruitment opportunities for Hairy Joint Grass seedlings.
- Subject to future monitoring outcomes and results of the hand weeding and slashing, selective removal of *Pteridium esculentum* may assist in regeneration of Hairy Joint Grass. However this should only be considered if the removal of weed competition is not successful (as indicated by declining trends in the HJG population).
- Due to the broad cover abundance range within each Braun-Blanquet score, it is not possible to determine whether a substantial difference has occurred between sites where the Braun-Blanquet Scale score of '3' (i.e. 5-25% cover) or above has been applied as the percent range exceeds the 15% threshold for detecting change. A smaller percent cover score (e.g. 1-5% increments) should be considered for future monitoring to improve the ability to detect change

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1. Introduction

1.1 Context

As part of the Frederickton to Eungai (F2E) Pacific Highway Upgrade Project (the Project), Roads and Maritime Services (Roads and Maritime) have implemented an Ecological Monitoring Program (hereafter referred to as the 'EMP') in accordance with the Minister for Planning's Condition of Approval (MCoA) No. 3.1. This EMP (RMS 2016) combines the approval conditions provided within the Ministers Conditions of Approval (MCoA) and Statement of Commitments (SoC), and defines the mitigation and offsetting requirements for threatened species and ecological communities impacted by the Project.

Hairy Joint Grass (HJG, *Arthraxon hispidus*) was one threatened species identified as requiring mitigation and monitoring through the course of the Projects' construction and operational period. The monitoring requirements for this species are outlined within the EMP.

1.1.1 Legal status

HJG is listed as vulnerable under the Commonwealth *Environment Protection and Biodiversity Conservation Act* (EPBC Act 1999) and the New South Wales *Threatened Species Conservation Act* (TSC Act 1995). HJG is in the family Poaceae (grasses) and has a global distribution. The genus *Arthraxon* contains about 25 species and is distributed across parts of Asia, India and Africa. HJG itself is considered an invasive weed in North America. In Australia the species is distributed from around Kempsey northwards.

1.1.2 Monitoring framework

The EMP states the following regarding monitoring.

"Monitoring would commence in the summer-autumn of 2014 and be undertaken three times a year up between the start of summer to the end autumn until 2019." [sic]

To date, these monitoring events have been reported on as follows:

- *February, April and May 2015*: Niche 2016.
- *December 2015, February and April 2016*: Niche 2017.
- *December 2016, February and May 2017*: current report.

1.1.3 Baseline data

The EMP provides the following baseline data:

"1. Southern population occurs at chainage 24000 and occurred over a mapped extent of 3.71 ha in March 2012 (Richards 2012). The Project will remove approximately 0.55 ha with a further 0.27 ha retained within the Project corridor which may be subject of indirect impacts including weed invasion, sedimentation, changed in hydrology and soil eutrophication. The existing landuse is pasture production for beef and cattle grazing with this area supporting Kikuyu, Paspalum, Carpet Grass and Bladey Grass. Fertilizer applications in the form of super phosphate were historically applied to this area up until about 2007. The western boundary of the mapped extent extends into the North Coast Railway Corridor which contains rank grassland and early successional plants such as Acacia.

2. Northern population occurs at chainage 29500 and occurred over a mapped extent of 2.43 ha in March 2012 (Richards 2012). The Project was re aligned to avoid the majority of this population. Fence line clearing for the Project will remove approximately 0.007 ha. A further 0.027 ha is retained within the Project corridor

which may be subject of indirect impacts. The existing landuse is pasture production for beef cattle grazing with this area supporting Paspalum, Carpet Grass and occasionally Kikuyu and White Clover. Fertilizer applications in the form of super phosphate are not known at this location.

At both locations, the plants occur sporadically throughout the mapped extend with Braun-Blanquet scale ranging from r (<<<1(solitary, insignificant cover) to 2 (10-25%) in 2 x 2 m quadrants (4m²).” [sic]

1.1.4 Purpose of this report

This report complies with the monitoring requirements described within the EMP and details the findings obtained from the third monitoring event.

The aims of this report are to summarise the methods and results of the 2016/2017 monitoring, provide an overall discussion of all monitoring events and determine if performance measures have been met, as per the EMP.

1.2 Performance measures

The EMP specifies the following performance indicators for HJG.

Indicators of success will focus on the following:

- *Exclusion fencing with signage identifying ‘no go’ zones (during construction).*
- *Sediment control fencing in place and working effectively (during the construction period).*
- *Review of the design of drainage and planning of works (during the construction period).*
- *Flowering and/or seeding is consistent with paired control or previous monitoring results.*

Signs of the habitat protection procedure not working will be based on the following:

- *Breached exclusion fencing (during construction).*
- *No signage identifying the sensitive nature of the location as threatened species habitat (during construction).*
- *A significant (if statistics are used) or substantial difference (i.e. 15% allowance) between the paired monitoring sites or impact only monitoring sites with regard to flowering/seeding and overall extent or recruitment.*

1.3 Monitoring timing

As per the EMP, monitoring is to be undertaken three times a year, between the start of summer to the end autumn.

1.4 Reporting

Annual reporting of monitoring results will outline:

- A description of the monitoring methodology employed.
- Results of the monitoring surveys.
- A discussion of the results, including how the results compare against key performance criteria.
- The need for any corrective actions/contingency measures and any general recommendations.

All reports prepared under the EMP will be submitted to the Director General of the NSW Department of Planning and Environment and the NSW Environment Protection Authority (EPA).

1.5 Limitations

The following limitations were present during the current monitoring period:

- The 3CN control site is considered to be unsuitable to be used in statistical comparisons with the other sites due to the difference in the condition treatment of this site (3CN site is grazed) that may itself result in any differences seen.
- Due to the broad cover abundance range within each Braun-Blanquet score, it is not possible to determine whether a substantial difference has occurred between sites where the Braun-Blanquet Scale score of '3' (i.e. 5-25% cover) or above has been applied, as the percent range exceeds the 15% threshold for detecting change. A smaller percent cover score (e.g. 1-5% increments) should be considered for future monitoring to improve the detectability of change.

2. Survey Methods

2.1 Survey sites

Six monitoring sites were originally identified for HJG monitoring (Lewis 2013). These included three potential impact sites (located within the Project boundary) and a paired control site (located outside of the Project boundary). However, following the completion of the first (February 2015) monitoring event (where all six sites were monitored), two of the three paired control sites could not be surveyed as landholder agreements for access had not been secured. In accordance with the EMP these two control sites have been removed from the monitoring program. The locations of the four remaining monitoring sites are provided in Figure 1 and detailed in Table 1. Future monitoring of the 3CN control site is subject to landowner agreement (RMS 2016).

Table 1: Details of potential impact sites and control site

Monitoring site	Chainage/ Location	Easting	Northing	Site type	Side of Carriageway	No. 2 x 2m Quadrats	Landholder Access Agreement Status
1HE	24000	487175	6576696	potential impact	East	10	Not required
2HW	24000	487173	6576695	potential impact	West	10	Not required
3HN	29500	491349	6580096	potential impact	North	10	Not required
3CN	29500	491261	6580161	control	North	10	Access granted

2.2 Survey method

Monitoring was undertaken in December 2016 (summer 1), February 2017 (summer 2) and May 2017 (autumn). At each site ten 4 m² quadrats were surveyed and the following information was recorded for each 4 m² quadrat:

- Plant species present and relative cover of all species using the Braun-Blanquet scale (Table 2).
- The extent of flowering and/or seeding HJG.
- Signs of disturbance (i.e. cattle), sedimentation and to what extent/area.
- A photo taken from a designated photo point.

Table 2: Braun-Blanquet cover abundance scale used in each 4 m² quadrat

Score	Cover Abundance Category
1	1-5% cover – rare
2	1-5% cover – common
3	6-25% cover
4	26-50% cover
5	51-75% cover.
6	76-100% cover

2.3 Analysis of data

Statistical analyses have not been performed due to the lack of paired control sites. In addition, the 3CN control site is considered to be unsuitable to be used in statistical analyses due to the difference in the condition treatment of this site (3CN site is grazed) that may itself result in any differences seen. Instead, the latest monitoring results for each of the four sites are compared with previous monitoring results and assessed for substantial differences (15% allowance) in flowering/seeding and overall extent or recruitment. It should however be noted that due to the broad cover abundance range within each Braun-Blanquet score, it is not possible to determine whether a substantial difference has occurred using the Braun-Blanquet Scale score of '3' (i.e. 5-25% cover) or above between neighbouring scores, as the percent range exceeds the 15% threshold for detecting "substantial change". Where appropriate and possible, a substantial difference in the percentage of quadrats recording HJG, flowering/seeding and recruitment has been determined.

3. Results

3.1 Monitoring results

Field data is provided in Annex 1 and a summary of the results is provided in Table 3 and Table 4. Substantial decreases between successive monitoring events (> 15%) are highlighted in bold. Results of photo monitoring are provided in Annex 2.

3.1.1 HJG presence/cover abundance

HJG was recorded at two of the impact sites (1HE and 2HW) and at the 3CN control site during the 2016/2017 monitoring period. Competition with exotic perennial grasses was again evident during the current monitoring.

Site 1HE

HJG has been recorded at this site at least once during all three monitoring events with consistently low cover abundance and total quadrats recording HJG (n = 3, 6 and 5 respectively) over successive years.

Site 2HW

HJG has been recorded at this site during all monitoring events, with a relatively consistent cover abundance score. Total quadrats recording HJG has decreased over the 2014/2015 (n = 25, 83%), 2015/2016 (n = 23, 77%) and 2016/2017 (n = 20, 67%) monitoring events. **This equates to a substantial decrease (>15%) in the HJG records between the 2014/2015 and 2016/2017 monitoring events.**

Site 3HN

HJG remained absent from impact site 3HN. The site contained thick introduced grass cover consistent with the results of the previous monitoring period in 2015/16. Some grazing or slashing may have occurred prior to the summer 1 monitoring event (see Annex 2).

Site 3CN

While data is not available for all surveys during previous monitoring events due to private property access restrictions, **there has been a substantial decrease in the detection of HJG at the control site as HJG was recorded in only a single quadrat in the 2016/2017 surveys compared to at least nine quadrats in each of the previous years' surveys.** Site 3CN has been heavily grazed.

3.1.2 Flowering/seeding and recruitment

During the 2016/2017 monitoring flowering/seeding and recruitment were observed only at site 2HW. Substantial decreases between successive monitoring events (> 15%) are highlighted in bold.

Site 1HE

Flowering/seeding and recruitment has been recorded previously at this site but only in single quadrats. The absence of flowering/seeding and recruitment in 2016/2017 is not considered to represent a substantial decrease.

Site 2HW

Flowering/seeding and recruitment has been recorded during all three monitoring events. However, total quadrats recording flowering/seeding has decreased over the 2014/2015 (n = 8, 27%), 2015/2016 (n = 6, 20%) and 2016/2017 (n = 20, 7%) monitoring events. **This equates to a substantial decrease (>15%) in the flowering/seeding records between the 2014/2015 and 2016/2017 monitoring events.** Recruitment at this

site also decreased between 2015/2016 (n = 10, 33%) and 2016/2017 (n = 4, 13%). **This equates to a substantial decrease (>15%) in the recruitment records between the 2015/2016 and 2016/2017 monitoring events.**

Site 3HN

Flowering/seeding and recruitment has not been recorded at this site during any monitoring event.

Site 3CN

While data is not available for all surveys during previous monitoring events due to private property access restrictions, **there has been a substantial decrease in the flowering/seeding recorded between 2015/2016 (n = 8, 27%) and 2016/2017 (n = 0) at the control site.**

Table 3: Summary of Hairy Joint Grass monitoring results – presence/abundance

Site	# of Q w/ HJG									Score (mean ± se)								
	14/15			15/16			16/17			14/15			15/16			16/17		
	Summer 1	Autumn 1	Autumn 2	Summer 1	Summer 2	Autumn	Summer 1	Summer 2	Autumn	Summer 1	Autumn 1	Autumn 2	Summer 1	Summer 2	Autumn	Summer 1	Summer 2	Autumn
1HE	1	1	1	0	1	5	4	0	1	2	2	1	0	0.2±0.2	1.1±0.4	1.5±0.3	0	1
2HW	9	8	8	6	8	9	8	7	5	2.5±0.2	1.9±0.2	1.1±0.2	0.9±0.3	2±0.3	2.4±0.4	1.9±0.1	1.9±0.3	1
3HN	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3CN	10	ND	ND	9	10	10	1	0	0	1.5±0.2	ND	ND	1.7±0.3	3.4±0.2	2.8±0.2	1	0	0

ND = No data due to private property access restrictions.

Table 4: Flowering/seeding and recruitment

Site	F/S									R								
	14/15			15/16			16/17			14/15			15/16			16/17		
	Summer 1	Autumn 1	Autumn 2	Summer 1	Summer 2	Autumn	Summer 1	Summer 2	Autumn	Summer 1	Autumn 1	Autumn 2	Summer 1	Summer 2	Autumn	Summer 1	Summer 2	Autumn
1HE	0	1	0	0	0	1F	0	0	0	0	0	0	0	0	1	0	0	0
2HW	0	8	0	0	0	6S	1F	0	1F	0	0	3	6	0	4	1	3	0
3HN	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3CN	0	ND	ND	0	0	8S	0	0	0	0	ND	ND	0	0	3	0	0	0

S=Seeding, F=Flowering, R = recruitment (no of quadrats)

4. Discussion

4.1 Performance measures

A discussion of the 2016/2017 monitoring results in relation to the performance measures is provided in Table 5. As discussed previously (Section 2.3), the 3CN control site is considered to be unsuitable to be used in statistical comparisons due to the difference in the condition treatment of this site (3CN site is grazed) that may itself result in any differences seen, as such control site 3CN has been excluded from the discussion of performance indicators. Instead, the latest monitoring results for each of the four sites are compared with previous monitoring results and assessed for substantial differences (15% allowance) in flowering/seeding and overall extent or recruitment.

Table 5: Indicators of Success

Indicators of success	Discussion
Exclusion fencing with signage identifying 'no go' zones (during construction).	This performance indicator no longer applies as the construction period is complete and this section of the highway is now operational.
Sediment control fencing in place and working effectively (during the construction period).	This performance indicator no longer applies as the construction period is complete and this section of the highway is now operational.
Review of the design of drainage and planning of works (during the construction period).	This performance indicator no longer applies as the construction period is complete and this section of the highway is now operational.
Flowering and/or seeding is consistent with paired control or previous monitoring results.	This performance indicator has been met for all sites except Site 2HW. Total quadrats recording flowering/seeding has decreased over the 2014/2015 (n = 8, 27%), 2015/2016 (n = 6, 20%) and 2016/2017 (n = 20, 7%) monitoring events, with a substantial decrease observed between 2014/2015 and 2016/2017.

Table 6: Signs of the habitat protection procedure not working

Signs of habitat protection procedure not working	Discussion
Breached exclusion fencing (during construction).	This performance indicator no longer applies as the construction period is complete and this section of the highway is now operational.
No signage identifying the sensitive nature of the location as threatened species habitat (during construction).	This performance indicator no longer applies as the construction period is complete and this section of the highway is now operational.
A significant ($p < 0.05$) or substantial difference (i.e. 15% allowance) between the paired monitoring sites or impact only monitoring sites with regard to flowering/seeding and overall extent or recruitment.	Comparisons between control and impact sites cannot be made due to the sites being exposed to different treatments which may confound the results (see Section 2.3) Comparisons between impact sites are similarly not suitable due to differences in site treatments and ecological variables. Between monitoring event comparisons of the same sites have therefore been used to detect differences in HJG presence/seeding and recruitment over time. To this end, this performance indicator of unsuccessful mitigation has not been met for sites 1HE and 3HN (i.e. there was no substantial difference in presence, flowering/seeding or recruitment between successive surveys) however it has been met for Site 2HW. There were substantial decreases in the HJG quadrat records and the flowering/seeding between the 2014/2015 and 2016/2017 monitoring events and in recruitment between the 2015/2016 and 2016/2017 monitoring events at this site.

5. Recommendations

As stated previously, control site 3CN has not been used for impact-control statistical comparisons within monitoring events. Likewise, overall seasonal trends observed for control site 3CN cannot be used to recognise and compare non-impact related trends due to the differences in landuse between this site and the impact sites and the lack of other control sites. As such, recommendations provided below are based only on within site data and comparisons.

5.1 Contingency measures

The EMP lists potential problems and contingency measures for various components of the monitoring program. Those that are considered to be relevant to the HJG monitoring program are listed and discussed in Table 7.

Table 7: Potential problems and contingency measures proposed for Hairy Joint Grass

Potential Problem	Contingency Measures proposed in EMP	Relevance of contingency measure
Significant difference ($p < 0.05$ level) in flowering/seeding and/or extent of relative cover between control sites and treatment sites, or over consecutive monitoring events with impact only monitoring sites.	Review drainage (local hydrological patterns) Review the need for additional management such as mowing and removal of mulch.	This contingency measure is considered relevant to Site 2HW only. Substantial decreases were found for the HJG quadrat records and flowering/seeding between successive monitoring events at this site.

5.2 Corrective actions to meet performance criteria

The recommendations provided in Table 8 aim to address proposed contingency measures and to meet performance criteria.

Table 8: Recommendations

Relevant contingency measure or performance indicator	Application	Recommendations
Review drainage (local hydrological patterns).	Site 2HW	Local drainage cannot be changed at the site.
Review the need for additional management such as mowing and removal of mulch.	Site 2HW	It is recommended that careful bush regeneration activities be undertaken at the site and area immediately surrounding it. In particular, weed management should entail careful hand weeding of introduced grasses (e.g. <i>Andropogon virginicus</i> , <i>Senecio madagascariensis</i> etc.).
Flowering and/or seeding is consistent with paired control or previous monitoring results.	Site 2HW	It is also recommended that slashing, preferably in winter (June – August) be undertaken. This may provide recruitment opportunities for HJG seedlings. Recommended slashing entails slashing to 3 cm height. Slashing should avoid any standing HJG plants, although the plant is considered to be an annual or to die-back significantly during winter. An ecologist familiar with the species should be present during slashing to ensure that HJG individuals are avoided.

Relevant contingency measure or performance indicator	Application	Recommendations
<p>A significant ($p < 0.05$) or substantial difference (i.e. 15% allowance) between the paired monitoring sites or impact only monitoring sites with regard to flowering/seeding and overall extent or recruitment.</p>	<p>Site 2HW</p>	<p>Subject to future monitoring and results of the hand weeding and slashing, selective removal of some <i>Pteridium esculentum</i> may assist in the regeneration of HJG. However this should only be considered if the removal of weed competition is not successful (as indicated by declining HJG population trends).</p>

6. References

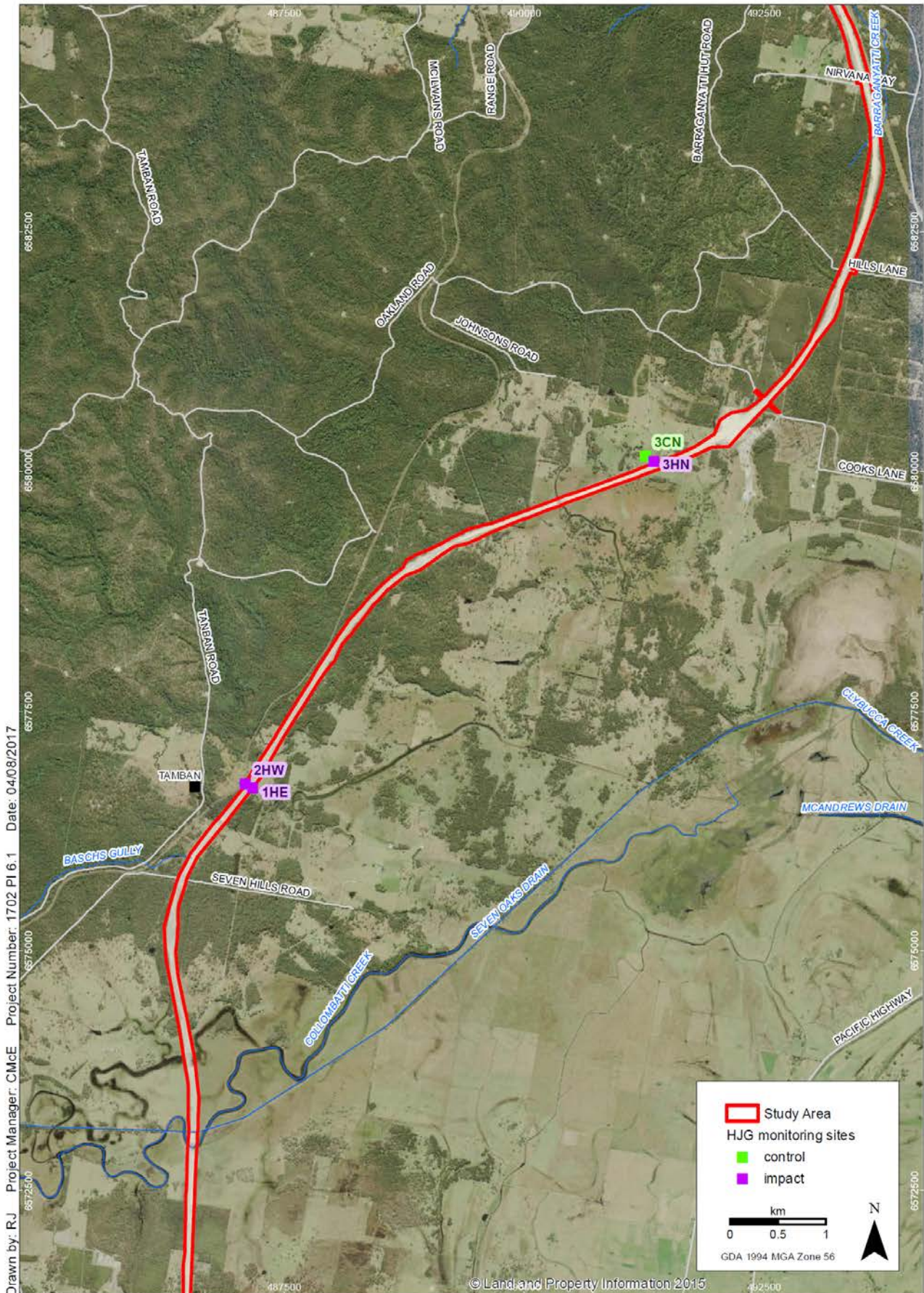
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F2E Hairy Joint Grass 2016/2017 Monitoring Locations
Pacific Highway Upgrade – Frederickton to Eungai

Annex 1. Results

Impact site 1HE (*Exotic species)

Species	S1										S2										A1										
Quadrat	1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6	7	8	9	10	
<i>Allocasuarina littoralis</i>			3																												
<i>Anagallis arvensis*</i>																															1
<i>Andropogon virginicus*</i>			3	4	4	6	4	6	5	4		2	5	2	5	3	4	6	6	5	3			4	5	4	5	4	5	4	5
<i>Arthraxon hispidus</i>	1	2	1				2																					1			
<i>Axonopus fissifolius*</i>				4		4				3																					
<i>Carex</i> spp.					2				2																						1
<i>Casuarina glauca</i>						2		2	2	4		2						1			4						1			6	
<i>Centella asiatica</i>								2					1											1	1			1	1		
<i>Convolvulus</i> spp.			1																												
<i>Conyza bonariensis*</i>								2											1						1				1		
<i>Cyperus brevifolius*</i>													2																		
<i>Cyperus</i> spp.*											1																				
<i>Dianella longifolia</i>					1																										
<i>Dichelachne micrantha</i>				3	4																										
<i>Dichondra repens</i>			2				2												1												2
<i>Festuca</i> spp.*	3																														
<i>Glycine tabacina</i>							2		2			1			1				2	1			1						1	2	2
<i>Hibbertia scandens</i>	1																														
<i>Hydrocotyle peduncularis</i>				2																										1	
<i>Hypericum gramineum</i>										1																					
<i>Hypochaeris radicata*</i>	2									1	1																				
<i>Imperata cylindrica</i>	6		4		4	4	5				5	4		6	6	5						3	4	3	4	6	4	5			

Species	S1										S2										A1											
Quadrat	1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6	7	8	9	10		
<i>Lachnagrostis filiformis</i>																					5		3							3		
<i>Microlaena stipoides</i>	4						4	3	4	4									2	2	2	4							3	3	5	3
<i>Oplismenus aemulus</i>					1																										3	
<i>Oxalis exilis</i>																														2		
<i>Parsonsia straminea</i>																															1	
<i>Paspalidium distans</i>																									4							
<i>Paspalum dilatatum*</i>	4		4	4				4	4		2	3	4	2	3			4		3	2	2			3		4					
<i>Persicaria</i> spp.													1																			
<i>Plantago lanceolata*</i>	3		3	3	3	3	3	2	2	3	2			1	2	3	2	2	2	2	1			1		2					2	
<i>Pratia purpurascens</i>																1		1		1												
<i>Pteridium esculentum</i>	3						3				2				1	4					2				1		6					
<i>Schoenus apogon</i>					2					2																						
<i>Senecio madagascariensis*</i>	2		2	3		3	2	3	2		2		2	2	1			2						3	3	3	3	3				
<i>Setaria pumila*</i>																														3		
<i>Sida rhombifolia*</i>																						2										
<i>Solanum nigrum*</i>								1																								
<i>Sporobolus fertilis*</i>											2								3	3		1										
<i>Verbena rigida*</i>	4		3	2	2		2	3	2		2					2	2			2	4	3			2		3	3				

S1 = Summer 1 (December 2016), S2 = Summer 2 (February 2017), A = Autumn (May 2017)

Impact site 2HW (*Exotic species)

Species	S1										S2										A1									
Quadrat	1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6	7	8	9	10
<i>Allocasuarina littoralis</i>	4																													
<i>Andropogon virginicus*</i>		4	4			3	2	4	4	4			5	2	3	3		3	4	3	4		4	2				4		3
<i>Arthraxon hispidus</i>	2	2		2	2	2	2	2	1					3	2	2	1	2	2	1			1			1	1	1	1	
<i>Axonopus fissifolius*</i>										3																				
<i>Calochlaena dubia</i>			1																											
<i>Carex</i> spp.	1	1					2				1	2			2															
<i>Centaureum spicatum</i>							2																							
<i>Centella asiatica</i>		2							3										1					1					1	1
<i>Commelina cyanea</i>								2									1		1	2					2	1	2	1	2	2
<i>Conyza bonariensis*</i>	1						2		3		1					3			2	3	2		2							
<i>Cynodon dactylon</i>																				2										
<i>Cyperus brevifolius*</i>																						1								
<i>Dichondra repens</i>	2	2				2	2											1	1		1	1	3		1	1	1			
<i>Digitaria</i> spp.												2												2		2				
<i>Eragrostis leptostachya</i>									3																		2	2		
<i>Eragrostis tenuifolia*</i>							3																							
<i>Festuca</i> spp.*		2																												
<i>Gamochaeta Americana*</i>																			1											
<i>Glycine tabacina</i>	2															1					1		2	1	2		2	2		
<i>Hypericum perforatum*</i>											1																			
<i>Hypochaeris radicata*</i>		3				2	3	2		2		2			2		2	2	2											
<i>Imperata cylindrica</i>			4		5				3				5	6		6	6	5	3		2		6	5		6		5	6	
<i>Juncus continuus</i>																						1								
<i>Lachnagrostis filiformis</i>																									2					

Species	S1										S2										A1									
Quadrat	1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6	7	8	9	10
<i>Microlaena stipoides</i>	2						3	4	3	3											2	3	4	4	4	3	3		4	3
<i>Oxalis exilis</i>		1				2		2										1			1		1						1	
<i>Parsonia straminea</i>																			2											
<i>Paspalum dilatatum*</i>	5	4				4		3	3		6	5	2		2					2	3								2	3
<i>Pennisetum clandestinum*</i>									3		3																			
<i>Plantago lanceolata*</i>	3	2	3		3	3	3		2	3	2	2			2	2	2	2	2	2	2		2	2		2	1	2		1
<i>Pratia purpurascens</i>																			1			1	2	1		2	1	1	2	1
<i>Pteridium esculentum</i>	4	4	4		4	4	3	3	3	3	1		4	5	2	2	3	4	4	3		6	4	4	5	4	6	3	6	4
<i>Senecio madagascariensis*</i>	3	2	3		2	3	3	3	3	3	3	2			2	2	2	2	2		3	1	2			3	3	2	2	2
<i>Setaria pumila*</i>																						2	3	3					2	
<i>Solanum nigrum*</i>																													1	
<i>Sporobolus fertilis*</i>					3						3				3			4	5	4	3					5		5		3
<i>Taraxacum officinale*</i>																									2			1		
<i>Trifolium dubium*</i>						2																								
<i>Verbena rigida*</i>	4	3	3		3		4	4	4	3	4	2	4	2		3	3	3	3	2		6	2	3	4	3	4	3	3	3
<i>Veronica</i> spp.	2	2									1		2								1									

S1 = Summer 1 (December 2016), S2 = Summer 2 (February 2017), A = Autumn (May 2017)

Impact site 3HN (*Exotic species)

Species	S1										S2										A1										
	1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6	7	8	9	10	
<i>Andropogon virginicus*</i>	2		4																						2					2	3
<i>Arthraxon hispidus</i>																															
<i>Axonopus fissifolius*</i>											4	3	3	3		4	5	4		4											
<i>Carex appressa</i>					2																										
<i>Centella asiatica</i>	2			2	2		2		2	2					1	1				1	2	2	1	2	2	2	1				1
<i>Cynodon dactylon</i>															2																
<i>Cyperus brevifolius*</i>															1																
<i>Dichelachne</i> spp.									1																						
<i>Digitaria sanguinalis*</i>																							4	4		4	4	4	5		
<i>Galium</i> spp.											4	3	3	3	3	3	2	3	2	2	3	3	3	3	3	2	2	3	3	3	3
<i>Geranium solanderi</i>																									1	1				1	
<i>Hydrocotyle peduncularis</i>									2																	1					2
<i>Juncus imbricatus*</i>																					1			2	2	2	2	2	1	1	
<i>Juncus usitatus</i>		3	2	2		2	3	2	2	2	2	2	2	2		2		1	2	2											
<i>Lachnagrostis filiformis</i>	3	4	4			3	3		4																						
<i>Paspalum dilatatum*</i>	6	6	6	4	5	6	6	5	6	6	5	6	6	4	6	6	6	6	5	6	5	6	5	5	6	5	4	5	3		
<i>Pennisetum clandestinum*</i>				6		5	4	5						5									4		3	4	3	3	4	6	6
<i>Plantago lanceolata*</i>	3			3	5	3		4		3			2	2							3	2	2	2	2	2	2	1	1	2	1
<i>Senecio madagascariensis*</i>	2		2		2	3		3	2	2			2	1	1	2	3				3	3	3	3	3	3	3	3	1	3	2
<i>Setaria pumila*</i>	3	4			4	3	4		5	4				4	3	3	4				4	5	5	4	3	4	6	4	4		
<i>Sporobolus fertilis*</i>					3																									2	
<i>Taraxacum officinale*</i>		1	2																												
<i>Trifolium dubium*</i>		3				2	3		2																						
<i>Trifolium repens*</i>																							2		2	1					







Control site 3CN (*Exotic species)







Species	S1										S2										A1									
	1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6	7	8	9	10
<i>Andropogon virginicus*</i>																								3				2		
<i>Arthraxon hispidus</i>						1																								
<i>Axonopus fissifolius*</i>	2	2		3	2	2	2	3	3	4	4	4	5	5	6	6	4	5	6	4										
<i>Bidens pilosa*</i>																											1			
<i>Briza subaristata*</i>								2																						
<i>Centella asiatica</i>								2														2	1		1	2		2	2	2
<i>Cynodon dactylon</i>	2	2	2					3		5										3										
<i>Cyperus</i> spp.						2		2													2									
<i>Dichelachne micrantha</i>										2																				
<i>Digitaria sanguinalis*</i>																					6	6	6	6	6	3	4	4	5	6
<i>Euchiton</i> spp.				1				2																						
<i>Gamochaeta Americana*</i>									1							1														
<i>Geranium solanderi</i>																					1	2			1			1	2	
<i>Gonocarpus tetragynus</i>								1																						
<i>Hydrocotyle peduncularis</i>																					1	2	1					1		1
<i>Hypochaeris radicata*</i>	2		2								2									1		2				3	2	2	1	2
<i>Juncus continuus</i>	2	2	2		3	3	3	2	3	2														2	1	1		2	2	1
<i>Juncus imbricatus*</i>																										1	2	2	2	3
<i>Juncus</i> spp.																						3	2	2						
<i>Juncus usitatus</i>											1		1	1	1	2	1	2	1											
<i>Lachnagrostis filiformis</i>			2					2	3													3								
<i>Lilaea scilloides*</i>				2																										
<i>Lolium perenne*</i>			2						2	3																				
<i>Microlaena stipoides</i>								2																						

Species	S1										S2										A1									
Quadrat	1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6	7	8	9	10
<i>Oxalis</i> spp.									1																					
<i>Paspalum dilatatum</i> *			3		3	3				4	5	6	4	5	4	3	3	4	3		5	5	5	5	3	5	6	5	5	4
<i>Pennisetum clandestinum</i> *	3	4	4	5	5	5	5	4	5	5	2		3	3	1	3	5	4	3	4	3	4	4	4	4	5	3	4	4	
<i>Plantago lanceolata</i> *	2	2	3	2			3	3	3		2	2	2	2	1	2	2	1	2	2		2	2	3	3	3	3	3	2	
<i>Portulaca</i> spp.						1	2																							
<i>Pratia purpurascens</i>																	1										1			
<i>Rumex crispus</i> *																								1		1				
<i>Senecio madagascariensis</i> *	2	2	4	2	2	2	2	3	4	3	1		1		1	1		1	1	2				2	2	2	2	2		
<i>Setaria pumila</i> *					2	2			2														3		3	4	4	4	3	3
<i>Solanum nigrum</i> *								1																1						
<i>Sporobolus fertilis</i> *																									4	2		3		2
<i>Taraxacum officinale</i> *				1			2	2	2		2	2	1	1		2	1						2	2	2		1	2		
<i>Trifolium dubium</i> *				2		3								1	1			1												
<i>Trifolium repens</i> *			3			2	2		2	2											2	3	2	2	2	2	2	2	2	
<i>Verbena rigida</i> *								1																						

S1 = Summer 1 (December 2016), S2 = Summer 2 (February 2017), A = Autumn (May 2017)

Annex 2. 2016/2017 photo monitoring

Site ID	Summer 1 (December 2016)	Summer 2 (February 2017)	Autumn (April 2017)
1HE impact site			
2HW impact site			

Site ID	Summer 1 (December 2016)	Summer 2 (February 2017)	Autumn (April 2017)
3HN impact site			
3CN control site			

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Appendix B *Maundia triglochinodes*



Maundia triglochinoidea Monitoring 2016/2017

Frederickton to Eungai Pacific Highway Upgrade

Prepared for Roads and Maritime Services

16 August 2017

Document control

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Project Manager:	Radika Michniewicz
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Cover photographs: *Maundia triglochinos*

Executive summary

Context

This report documents the 2016/2017 monitoring period (December 2016, February 2017 and May 2017) for *Maundia triglochinoxoides* as required by the Frederickton to Eungai (F2E) Ecological Monitoring Program (RMS 2016).

Aims

Roads and Maritime Services is required to manage and monitor the effectiveness of the biodiversity mitigation measures implemented as part of the Project. This includes monitoring of *Maundia triglochinoxoides* which occurs within the Project area. The aims of this report are to summarise the methods and results of the 2016/ 2017 monitoring, provide a discussion of monitoring events and determine if performance measures have been met, as per the EMP (RMS 2016).

Methods

The 2016/2017 monitoring methodology is consistent with the methods developed and used in 2016, based on a 50 m x 2 m belt transect (i.e. 100 m²) within *Maundia triglochinoxoides* habitat at each site to improve the data analysis.

Five paired impact-control and six impact-only monitoring sites were surveyed in accordance with the monitoring method specified in the EMP (RMS 2016). In addition, three reference sites have been included in the monitoring program.

Key results

Cover Abundance

Maundia was recorded on at least one occasion at three of the five paired impact sites and at all five paired control sites, at all three reference sites and on at least one occasion at five of the six impact-only sites during the 2016/2017 monitoring period.

Recruitment and Flowering/Seeding

Recruitment was not recorded at any of the paired impact sites. Recruitment was only recorded at one of the five paired control sites, three of the six impact-only sites and one of the three the reference sites. Flowering/seeding was recorded at two paired impact-control sites, was absent from two paired impact-control sites and present in the control only at one paired impact-control site. Flowering/seeding was recorded at one reference site and three of the six impact-only sites.

Conclusions

Performance measures of success relating to flowering/seeding between paired impact-control sites have not been met for site MI05 and between monitoring events for sites MI03W, MI08 and MI09.

Performance measures of unsuccessful mitigation relating to flowering/seeding and recruitment between paired impact-control sites have been met for sites MI01, MI02, MI05 and MI10 and between successive monitoring events for site MI02.

Management implications

A number of recommendations to meet performance criteria should be considered and include:

- Weed control may be employed at the site, specifically hand weeding around *Maundia* patches targeting weeds and over abundant native species (such as *Persicaria* spp.).
- Where possible, cattle should be excluded from the control sites.
- Maintain existing fences and exclusion zones.

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1. Introduction

1.1 Context

As part of Frederickton to Eungai (F2E) Pacific Highway Upgrade Project (the Project), Roads and Maritime Services (Roads and Maritime) have implemented an Ecological Monitoring Program (EMP) in accordance with the Minister for Planning's Condition of Approval (MCoA) No. 3.1. This EMP (RMS 2016) (hereafter referred to as EMP) combines the approval conditions provided within the Minister's Conditions of Approval (MCoA) and Statement of Commitments (SoC), and defines the mitigation and offsetting requirements for threatened species and ecological communities impacted by the Project.

Maundia triglochinos (Maundia) was one threatened species identified as requiring mitigation and monitoring through the course of the Projects' construction and operational period. The monitoring requirements for this species are outlined within the approved EMP.

1.1.1 Legal status

Maundia is listed as vulnerable on the New South Wales *Threatened Species Conservation Act 1995* (TSC Act). Monitoring of the species is required under the Project's approval.

1.1.2 Monitoring framework

The approved EMP states the following regarding monitoring.

"Monitoring would commence in the summer of Year 2014 and be undertaken three times a year up until Year 2019 of the project." [sic]

To date, these monitoring events have been reported as follows:

- *February, April, May 2015*: Niche 2016.
- *December 2015, February, April 2016*: Niche 2017.
- *December 2016, February, May 2017*: current report.

This report therefore represents the third of five required monitoring cycles.

1.1.3 Baseline data

The EMP provides the following background information for the Maundia populations within and adjacent to the Project in relation to the known locations:

"Maundia triglochinos populations are known from at least 36 locations within the vicinity (i.e. <2 km) of the Project extending from CH14200 to CH31100 (Lewis 2013). Combined, this mapped extent was estimated at 29.86 ha in March-August 2012. Individual location data is provided in Appendix A (Table A1 and A2)". [sic]

No data detailing relative cover abundance (i.e. Braun Blanquet scores), incidence of flowering/ seeding or recruitment was provided as part of this baseline dataset.

1.1.4 Purpose of this Report

This report complies with the monitoring requirements described within the approved EMP and details the findings obtained from the third monitoring event. This report therefore represents the third of five required reports.

The aims of this report are to summarise the methods and results of the 2016/2017 monitoring and determine if performance measures have been met, as per the EMP.

1.2 Performance measures

The approved EMP specifies the following performance measures for Maundia.

Indicators of success will focus on the following:

- *Exclusion fencing in place with signage identifying these as 'no go' zones (during construction).*
- *Sediment control fencing in place (during construction).*
- *Flowering and/or seeding is consistent with paired control and/or nearest reference site.*
- *Flowering and/or seeding at impact site is consistent with previous monitoring results.*

Signs of the habitat protection procedure not working will be based on the following:

- *Breached exclusion fencing (during construction).*
- *No signage in place identifying the sensitive nature of the location as threatened species habitat (during construction).*
- *A significant (if statistics are used) or substantial difference (i.e. 15% allowance) between paired monitoring sites (those within and those outside of the Project Area boundary) with regard to flowering/seeding and overall extent or recruitment that cannot be attributed to environmental factors.*
- *A significant (if statistics are used) or substantial difference (15% allowance) between impact monitoring sites over subsequent monitoring events that cannot be attributed to environmental factors.*

1.3 Monitoring timing

The monitoring program specifies that monitoring surveys commence in the summer of Year 2014 (construction phase) and be undertaken three times a year between the beginning of summer and the end of autumn until Year 2019 (operational phase) of the Project.

1.4 Reporting

Annual reporting of monitoring results outline:

- A description of the monitoring methodology employed.
- Results of the monitoring surveys.
- A discussion of the results, including how the results compare against key performance criteria.
- The need for any corrective actions/contingency measures and any general recommendations.

All reports prepared under the EMP will be submitted to the Director General of the NSW Department of Planning and Environment and the NSW Environment Protection Authority (EPA).

1.5 Limitations

The following limitations were present during the current monitoring period:

- Detection of *Maundia triglochinos* was not possible in areas where access was limited or water depth was relatively high. The number and cover abundance of seedling and recruiting individuals was not able to be recorded in such areas.
- Other variables, including shade, soil quality, water temperature, width of the habitat at each monitoring site, flora competition or water flow rate, that may impact upon the population were not recorded as part of the monitoring program.
- Between year comparisons for cover extent were limited to a range estimate derived from the Braun-Blanquet scale in 2014/2015 surveys.

2. Survey Methods

2.1 Survey sites

Monitoring design is consistent with that specified in the approved EMP. Five paired impact-control sites and six impact-only sites were monitored. Each paired site includes one impact location within the Project boundary and one control location outside the Project boundary. Due to access restrictions (Niche 2016), the revised EMP (RMS 2016) has excluded control sites MC03E, MC03W, MC04, MC07, MC08 and MC09 from the program. These locations are to be monitored via an impact site only. Site locations are shown in Figure 1, Figure 2 and Figure 3, with details provided in Table 1.

Table 1: Monitoring sites

Site	Chainage (Location)	Easting	Northing	Paired Control plot for potential impact plot	Easting of Control Plot	Northing of Control Plot
1	15360 (East)	487671	6568746	100 m downstream	487723	6568775
2	17360 (East)	486650	6570499	50 m downstream	486727	6570489
3E	19200 (East)	486461	6572090	Impact only	n/a	n/a
3W	19200 (West)	486546	6572155	Impact only	n/a	n/a
4	19950 (West)	486484	6572948	Impact only	n/a	n/a
5	20100 (East)	496604	6573123	100 m downstream	496604	6573123
6	20850 (East)	486531	6573953	100 m downstream	486564	6573899
7	23800 (East)	487058	6576563	Impact only	n/a	n/a
8	24425 (East)	487403	6577089	Impact only	n/a	n/a
9	24450 (West)	487352	6577162	Impact only	n/a	n/a
10	30275 (South)	492027	6580246	50 – 100 m downstream	491981	6580190

n/a = not applicable

All sites were surveyed during the three monitoring events in 2016/2017.

Three external reference sites, in Table 2, were also surveyed. These sites are independent of the Project area with the purpose of comparative monitoring of *Maundia* populations in the broader area. It is assumed that any change detected at these sites would be unrelated to the impacts of road construction or operation. Due to access restrictions (Niche 2016), the revised EMP (RMS 2016) excluded site 13- Old Stock Dam from future monitoring, and the previous Site 14 (Tamban Road) has become the “new” Site 13 in the EMP. For comparative purposes across monitoring / reporting events, reports will continue to refer to this site as Site 14 (Tamban Road).

Table 2: Reference sites

Site	Easting	Northing	Reference site name
11	490652	6581695	Cols Causeway
12	484393	6571941	Collombatti-Tamban Road
14	486641	6576627	Tamban Road

2.2 Survey method

As per the modified methodology in Niche 2016, the 2017 monitoring was undertaken within a 50 m x 2 m belt transect (i.e. 100 m²) within Maundia habitat at each site. Cover abundance was recorded as percent cover using 5% increments to be able to identify a “substantial difference” (i.e. 15% allowance, as per the EMP) between paired monitoring sites. This modified methodology was presented in Niche 2016 and allows for improved data collection and analysis whilst still complying with the EMP. The modified methodology is consistent with Native Vegetation Interim Standard (NVIS) and BioBanking Assessment Methodology (BBAM) 2014 for estimating number of stems and percentage cover of plant species along a transect. Every 2 m, a 2 m x 2 m quadrat was established along the transect (i.e. at 0 m to 2 m, 2 m to 4 m etc.) where the number of Maundia individuals, flowering, seeding and percent cover were recorded. The following data was collected at each of the monitoring sites:

- Number of Maundia individuals
- The extent of flowering or seeding
- Signs of recruitment
- Percent cover of Maundia using 5% increments
- Average water depth
- Signs of disturbance (i.e. cattle) and to what extent/area
- Photo from installed specific photo point.

Where a 50 m belt transect could not be achieved due to site geometry or limitations, the transect was extended as far as possible.

2.3 Analysis

The EMP specifies the following approach to the data analysis.

“For those sites subject to paired impact, control monitoring, a paired t test or a non-parametric equivalent (i.e. Mann Whitney) will be used to explore the usefulness of statistics in comparing the data set.” [sic]

Many of the paired impact-control sites established in the EMP are spatially close to each other and are unlikely to be independent. For example, most control sites located downstream of their paired impact site continue to be influenced by livestock grazing, while the impact site is no longer subject to this land use activity (due to Project boundary fencing) and this could be the reason for any observed changes.

Site independence is a fundamental assumption required by all statistical analyses. Additionally, the dataset is non-normal and could not be normalised with standard transformations. Therefore the use of statistical analyses for this data is not appropriate and a substantial difference (i.e. 15% allowance) (as per the performance measures provided in the EMP) has been used as the basis for identifying changes.

3. Results

Results summarising Maundia presence (% cover), recruitment and flowering for each of the sites are presented in Table 3 and Table 4. Field data is provided in Annex A.

3.1 Cover extent

The presence of Maundia and cover extent recorded at each impact and control site is presented in Table 3 and Table 4. Substantial differences (> 15%) between the cover extent of impact and control sites are highlighted in bold.

Photo monitoring results are presented in Annex B.

Paired impact-control sites

Maundia was recorded on at least one occasion at three of the five paired impact sites and at all five paired control sites during the 2016/2017 monitoring period. At the remaining two paired impact sites, MI06 and MI10, Maundia was not recorded during the 2016/2017 monitoring period.

- MI01 / MC01: A substantial difference in cover extent was recorded between the two sites in February 2017, however over the three surveys there was not a substantial difference in the average cover extent (12.4% at control site vs 1.4% at impact site).
- MI02 / MC02: A substantial difference between the control and impact site in the average cover extent over the three surveys was recorded, however the cover extent was greater at the impact site (26.4% at impact site vs 9.7% at control site).
- MI05 / MC05: A substantial difference in the cover extent between the sites was recorded in December 2016, however the average cover extent over the three surveys was not substantially different (5.7% at impact site vs 0.03% at control site).
- MI06 / MC06: A substantial difference in cover extent was not recorded as average cover extent at the control site was very low (0.03%). Maundia was previously recorded at MI06 during the 2015 and 2016 monitoring periods with a cover extent estimate of <5% in both monitoring periods.
- MI10 / MC10: A substantial difference in cover extent was not recorded as average cover extent at the control site was very low (3.5%). Previously Maundia was recorded at MI10 in both 2015 and 2016 with a low cover extent (<5%).

Impact-only sites and reference sites

Maundia was recorded at all three reference sites during the 2016/2017 monitoring period and on at least one occasion at five of the six impact-only sites. No Maundia was recorded during any survey at MI07.

- Reference site 12 is the nearest reference site to impact-only sites MI03E, MI03W and MI04. There was no substantial difference in the average cover extent between the impact-only sites (1.0%, 3.5%, and 14.4% respectively) and Reference site 12 (4.3%).
- Reference site 14 is the nearest reference site to impact-only sites MI07, MI08 and MI09. There was no substantial difference in the average cover extent between the impact-only sites MI08 and MI09 (0.7%, and 2.6% respectively) and Reference site 14 (0.3%). Maundia was not recorded at MI07. Similarly Maundia was absent from MI07 in 2015 (Niche 2016) but present on one occasion in 2016 (Niche 2017), with a low cover extent of less than 5%.

As in 2015/2016 (Niche 2016), Maundia was recorded at all three reference sites during the 2016/2017 monitoring period. However, cover extent was substantially lower in 2016/2017.

3.2 Recruitment

Maundia recruitment is presented in Table 3 and Table 4. Sites where recruitment was recorded at control sites but absent from paired impact sites are highlighted in bold.

Paired impact-control sites

At four of the five impact-control sites recruitment was recorded at the control site but not at the corresponding impact site. MI06/MC06 was the only paired site where no recruitment was observed at either the control or impact site. A description of recruitment at each of the paired sites follows:

- **MI01 / MC01:** A small number of recruiting individuals were recorded at the control site while no recruitment was recorded at the impact site.
- **MI02 / MC02:** A number of recruiting individuals were recorded at the control site while no recruitment was recorded at the impact site.
- **MI05 / MC05:** A large number of recruiting individuals were recorded at the control site while no recruitment was recorded at the impact site.
- MI06 / MC06: Recruitment was not recorded at the impact or control site.
- **MI10 / MC10:** A number of recruiting individuals were recorded at the control site while no recruitment was recorded at the impact site.

Impact-only sites and reference sites

- Reference site 12 is the nearest reference site to impact-only sites MI03E, MI03W and MI04. Recruitment was recorded at these three impact-only sites and at Reference site 12 with recruitment levels similar between MI03E and Reference site 12 and much higher at MI03W and MI04.
- Reference site 14 is the nearest reference site for impact-only sites MI07, MI08 and MI09. Recruitment was not recorded at any of these impact-only sites or at Reference site 14.

It should be noted that the ability to observe recruiting individuals of the species at some of the impact-control sites is likely to have been affected by factors such as water depth and presence of cattle which may graze recruiting individuals.

3.3 Flowering/Seeding

Maundia flowering/seeding results are presented in Table 3 and Table 4. Substantial differences (> 15%) between the % flowering/seeding at the impact and control/reference sites are highlighted in bold.

Paired impact-control sites

- MI01 / MC01: Flowering was recorded at both impact and control sites with a greater percentage of flowering individuals at the impact site.
- MI02 / MC02: Flowering was recorded at both impact and control sites at a similarly low level.
- **MI05 / MC05:** Flowering was recorded at the control site during one survey (16.8%) while no flowering was recorded at the impact site.
- MI06 / MC06: Flowering was not recorded at the impact or control site.
- MI10 / MC10: Flowering was not recorded at the impact or control site.

Impact-only sites and reference sites

- Reference site 12 is the nearest reference site to impact-only sites MI03E, MI03W and MI04. Flowering was only recorded at MI04 at low levels (average 1.2% of individuals over two surveys) and was not recorded at Reference site 12.
- Reference site 14 is the nearest reference site to impact-only sites MI07, MI08 and MI09. **Flowering was recorded at MI08 (35.5% one survey) and MI09 (average 27.0% of individuals over two surveys) but not at MI07 or Reference site 14.**

Table 3: Summary of Maundia presence, recruitment and flowering

Site Name	Design	<i>Maundia triglochin oides</i>			Cover extent in 100 m ² (%)		
		December 2016	February 2017	May 2017	December 2016	February 2017	May 2017
MI01	Impact	P, F	P	P	0.9	1.1	2.1
MC01	Control	P, F, R	P	P	7.2	20	9.9
MI02	Impact	P, F	P	P	27.6	19	32.6
MC02	Control	P, F	P, R	P	12.6	5.4	11.2
MI03E	Impact	P	N	P, R	0.2	0	2.66
MI03W	Impact	P	P	P, R	3	0.2	18.8
MI04	Impact	P, F, R	P, F, R	P	35	6	2.1
MI05	Impact	P	N	N	0.1	0	0
MC05	Control	P, F, R	P, R	P	16.8	0.2	0.2
MI06	impact	N	N	N	0	0	0
MC06	control	P	N	N	0.1	0	0
MI07	impact	N	N	N	0	0	0
MI08	impact	P, F	N	P	2	0	0.1
MI09	impact	P, F	P, F	P	4.8	0.4	2.7
MI10	impact	N	N	N	0	0	0
MC10	control	P, R	P, R	P	1.8	1.1	7.7

P = individuals present; F = flowering recorded; R = recruitment recorded; N = Maundia not recorded

Table 4: Maundia triglochinoides results for reference monitoring sites

Site Name	Design	<i>Maundia triglochin oides</i>			Cover extent in 100 m ² (%)		
		December 2016	February 2017	May 2017	December 2016	February 2017	May 2017
R11	reference	P, F, R	P, R	P	26.2	1.2	2.7
R12	reference	P, R	P	P	10	2.3	0.8
R14	reference	P	N	P	0.2	0	0.8

P = individuals present; F = flowering recorded; R = recruitment recorded; N = Maundia not recorded

3.4 Successive monitoring event assessment

A summary of previous monitoring events for impact sites is provided in Table 5. Averages were calculated over the three monitoring surveys for each monitoring event. Substantial decreases in cover extent, recruitment and flowering/seeding over successive monitoring events (> 15%) are highlighted in bold.

Results of the successive monitoring event assessments are described in Table 6.

Flowering/seeding was generally higher in 2015/2016 at all sites where flowering was recorded than the two other monitoring events. The occurrence of *Maundia* was also generally higher at all sites in 2015/2016.

Table 5: Summary of *Maundia* results

Report	2014/2015			2015/2016			2016/2017 (Current)		
Site	Average <i>Maundia</i> % cover ¹	Average Flowering % (n)	Average Recruitment (%)	Average <i>Maundia</i> % cover	Average Flowering % (n)	Average Recruitment (%)	Average <i>Maundia</i> % cover	Average Flowering % (n)	Average Recruitment (%)
MI01	6-25 (3)	<2 (1)	<1 (1)	8 (3)	0	0	1(3)	6 (1)	0
MI02	6-25 (3)	<7 (3)	23 (2)	27 (3)	33 (2)	Y (1)	26 (3)	<1 (1)	0
MI03E	1-5 (3)	0	<2 (1)	1 (2)	9 (1)	0	<1 (1)	0	2 (1)
MI03W	1-5 (3)	3 (1)	<3 (2)	27 (3)	36 (2)	0	7 (3)	0	2 (1)
MI04	0	0	0	39 (2)	3 (2)	Y	14 (3)	<1 (2)	3 (2)
MI05	0-5 (1)	0	0	<1 (3)	14 (1)	Y (1)	<1 (1)	0	0
MI06	1-5 (2)	<3 (2)	<1 (1)	1 (1)	Y (1)	0	0	0	0
MI07	0	0	0	2 (1)	33 (1)	Y (1)	0	0	0
MI08	0	0	0	<1 (2)	28 (1)	Y (1)	<1 (2)	12 (1)	0
MI09	0	0	0	1 (3)	39 (2)	0	3 (3)	18 (2)	0
MI10	0-5 (1)	0	0	<1 (1)	33 (1)	0	0	0	0

¹ = cover extent derived from Braun-Blanquet cover abundance scale used in 400m² quadrat methodology.

Y = recorded but no number or % available.

(n) = number of surveys recorded

Table 6: Successive monitoring outcomes

Site	Result	Substantial difference detected
MI01	Maundia was recorded during the three successive monitoring events without substantial changes in cover extent, flowering/seeding or recruitment.	
MI02	Maundia was recorded during the three successive monitoring events without substantial changes in cover extent or flowering/seeding.	Recruitment was high in 2014/2015, undefined in 2015/2017 and absent in 2016/2017.
MI03E	Maundia was recorded during the three successive monitoring events without substantial changes in cover extent, flowering/seeding or recruitment.	
MI03W	Maundia was recorded during the three successive monitoring events without substantial changes in recruitment.	Cover extent and flowering/seeding recorded a substantial decrease between 2015/2016 and 2016/2017.
MI04	Maundia was recorded only during the 2015/2016 and 2016/2017 surveys without substantial changes in flowering/seeding or recruitment.	Cover extent recorded a substantial decrease between 2015/2016 and 2016/2017.
MI05	Maundia was recorded during the three successive monitoring events without substantial changes in cover extent, flowering/seeding or recruitment.	
MI06	Maundia was recorded only during the 2014/2015 and 2015/2016 surveys without substantial changes in cover extent, flowering/seeding or recruitment.	
MI07	MI07: Maundia was recorded only during the 2015/2016 surveys at low cover extent on one occasion. The apparent substantial decrease in flowering/seeding in 2016/2017 cannot be considered as a real decrease in flowering/seeding as no individuals were recorded at this site during these surveys.	
MI08	MI08: Maundia was recorded only during the 2015/2016 and 2016/2017 surveys without substantial changes in cover extent or recruitment.	Flowering/seeding recorded a substantial decrease between 2015/2016 and 2016/2017.
MI09	Maundia was recorded only during the 2015/2016 and 2016/2017 surveys without substantial changes cover extent or recruitment.	Flowering/seeding recorded a substantial decrease between 2015/2016 and 2016/2017.
MI10	Maundia was recorded only during the 2014/2015 and 2015/2016 surveys without substantial changes in cover extent or recruitment. Flowering/seeding increased from 2014/2015 to 2015/2016.	

3.5 Mitigation measures

Exclusion fencing, signage for the ‘no go’ zones and sediment control fencing were not required for the 2017 monitoring period due to the highway being operational.

4. Discussion

4.1 Performance measures

A summary of the 2016/2017 survey results in relation to the performance indicators is provided in Table 7 and Table 8.

Table 7: Performance indicators of successful mitigation

Performance indicators of success	Discussion
Exclusion fencing with signage identifying these as 'no go' zones (during construction)	This performance indicator for 2016/2017 monitoring period is no longer applicable due to the road now being operational.
Sediment control fencing in place (during construction)	This performance indicator for 2016/2017 monitoring period is no longer applicable due to the road now being operational.
Flowering and/or seeding is consistent with paired control and/or nearest reference site	This performance indicator has been met by all but one of the five paired impact control sites. Flowering was not recorded at MI05 while its paired control site recorded 16.8% of flowering individuals.
Flowering and/or seeding at impact sites is consistent with previous monitoring results	This performance indicator has been met by all but 3 of the 11 impact sites. Flowering/seeding recorded a substantial decrease between 2015/2016 and 2016/2017 at impact sites MI03W, MI08 and MI09. Flowering/seeding was generally higher in 2015/2016 than during the two other monitoring events. The differences between the percentages of individuals flowering could be attributed to a number of factors, such as differing abiotic conditions across years, and varying annual weather conditions which may impact water flow, depth, turbidity, pH, nutrients, etc., and temperature. Given the species grows in warm conditions, this variable may impact upon the flowering times. The lower percent of individuals flowering in the 2016/2017 monitoring event therefore cannot be directly attributed to the Project.

Table 8: Performance indicators of unsuccessful mitigation

Performance Indicators of unsuccessful mitigation	Discussion
Breached exclusion fencing (during construction).	This performance indicator for 2016/2017 monitoring period is no longer applicable due to the road now being operational.
No signage in place identifying the sensitive nature of the location as threatened species habitat (during construction).	This performance indicator for 2016/2017 monitoring period is no longer applicable due to the road now being operational.
A significant (if statistics are used) or substantial difference (i.e. 15% allowance) between paired monitoring sites with regard to flowering/seeding and overall extent or recruitment that cannot be attributed to environmental factors.	This performance indicator of unsuccessful mitigation has been met for four of the five paired impact-control sites in relation to recruitment and at one of the five paired impact control sites in relation to flowering. Recruitment was recorded at control sites MC01, MC02, MC05 and MC10 but was absent from the paired impact sites. Flowering was substantially higher at MC05 than at the paired impact site. Environmental factors that may contribute to differences

Performance Indicators of unsuccessful mitigation	Discussion
	<p>between paired impact-control sites were not observed during the 2016/2017 monitoring. It should be noted that boundary fencing may introduce differences in landuse, however grazing, if present, at control sites could reduce recruitment. The opposite was observed here, with recruitment substantially reduced at paired impact sites.</p> <p>This performance indicator of unsuccessful mitigation has not been met in relation to extent/cover abundance for all impact-only sites for all criteria.</p>
<p>A significant (if statistics are used) or substantial difference (15% allowance) between impact monitoring sites over subsequent monitoring events that cannot be attributed to environmental factors.</p>	<p>This performance indicator of unsuccessful mitigation has been met for MI02. High recruitment was recorded in 2014/2015, undefined in 2015/2016 and absent in 2016/2017 (while recruitment remained present at its paired control site in 2016/2017).</p> <p>It is considered that observed substantial decreases between successive monitoring events at impact-only sites MI03W, MI04, MI08 and MI09 in flowering and cover extent are likely attributable to environmental factors as this trend was also observed at their nearest reference site.</p>

5. Recommendations

5.1 Contingencies

The EMP lists potential problems and contingency measures for various components of the monitoring program. Those that are considered to be relevant to the Maundia monitoring program are listed and discussed in Table 9.

Table 9: Potential problems and contingency measures proposed in the EMP

Potential Problem	Contingency Measure proposed in EMP	Relevance of contingency measure
Significant difference ($p < 0.05$ level) in flowering/seeding and/or extent of relative cover between control sites (adjacent road corridor) and treatment sites (habitat protection zones within road corridor) or within impact-only monitoring sites.	Review drainage (local hydrological patterns)	This contingency measure addresses only flowering/seeding and extent of cover. It was determined that there was no substantial difference between impact and control sites or between reference sites and impact-only sites for extent of cover. This contingency measure is considered relevant only for Site 5 where flowering was substantially higher at the control site than impact site.

5.2 Recommendations

The recommendations provided in Table 10 aim to address proposed contingency measures and to meet performance criteria.

Table 10: Recommendations

Relevant performance indicator or contingency measure	Application	Recommendations
Review drainage (local hydrological patterns)	Site 5: flowering was substantially higher at the control site than the impact site.	<p>The following recommendations have been made to enhance the existing population, which in turn may increase the number of flowering individuals and recruitment rates:</p> <ul style="list-style-type: none"> ▪ Weed control may be employed at the site, specifically hand weeding around Maundia patches targeting weeds and over abundant native species (such as <i>Persicaria</i> spp.). ▪ Where possible, cattle should be excluded from all sites. ▪ Maintain existing fences and exclusion zones.
Flowering and/or seeding is consistent with paired control and/or nearest reference site		
Significant difference ($p < 0.05$ level) in flowering/seeding and/or extent of relative cover between control sites (adjacent road corridor) and treatment sites (habitat protection zones within road corridor) or within impact-only monitoring sites.		
A significant (if statistics are used) or substantial difference (i.e. 15% allowance) between paired monitoring sites with regard to flowering/seeding and overall extent or recruitment that cannot be attributed to environmental factors.	Sites MC01, MC02, MC05, MC10: Recruitment was recorded at control but was absent from the paired impact sites.	Monitoring should continue for flowering and recruitment performance indicators. Should substantial decreases between flowering/seeding and recruitment indicators between the paired sites be observed over a number of years, then mitigation and management actions should be reviewed.

Relevant performance indicator or contingency measure	Application	Recommendations
Flowering and/or seeding at impact sites is consistent with previous monitoring results	MI03W, MI08 and MI09: Substantial decreases between successive monitoring events are likely attributable to environmental factors	
A significant (if statistics are used) or substantial difference (15% allowance) between impact monitoring sites over subsequent monitoring events that cannot be attributed to environmental factors.	MI02: High recruitment was recorded in 2014/2015, undefined in 2015/2016 and absent in 2016/2017.	

6. References

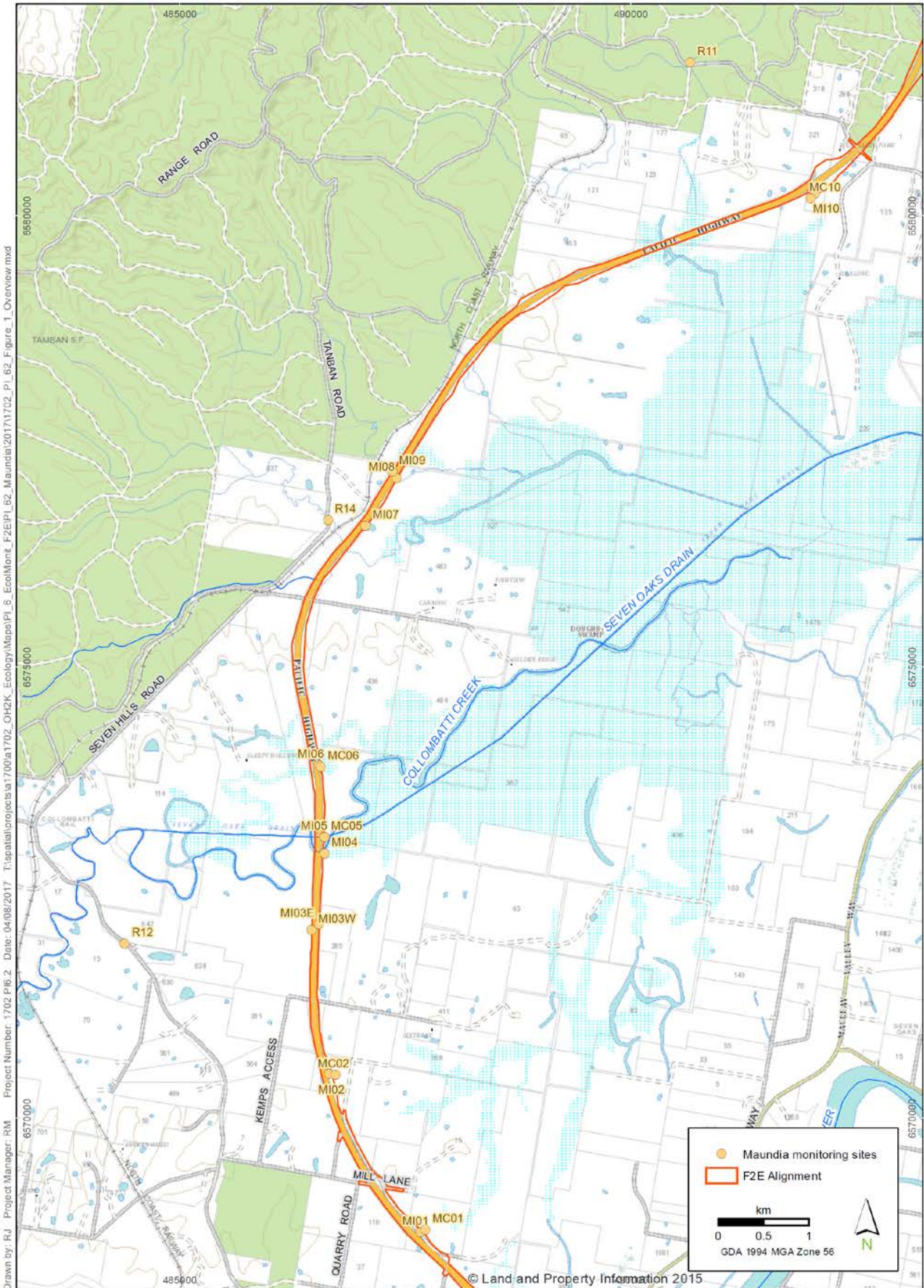
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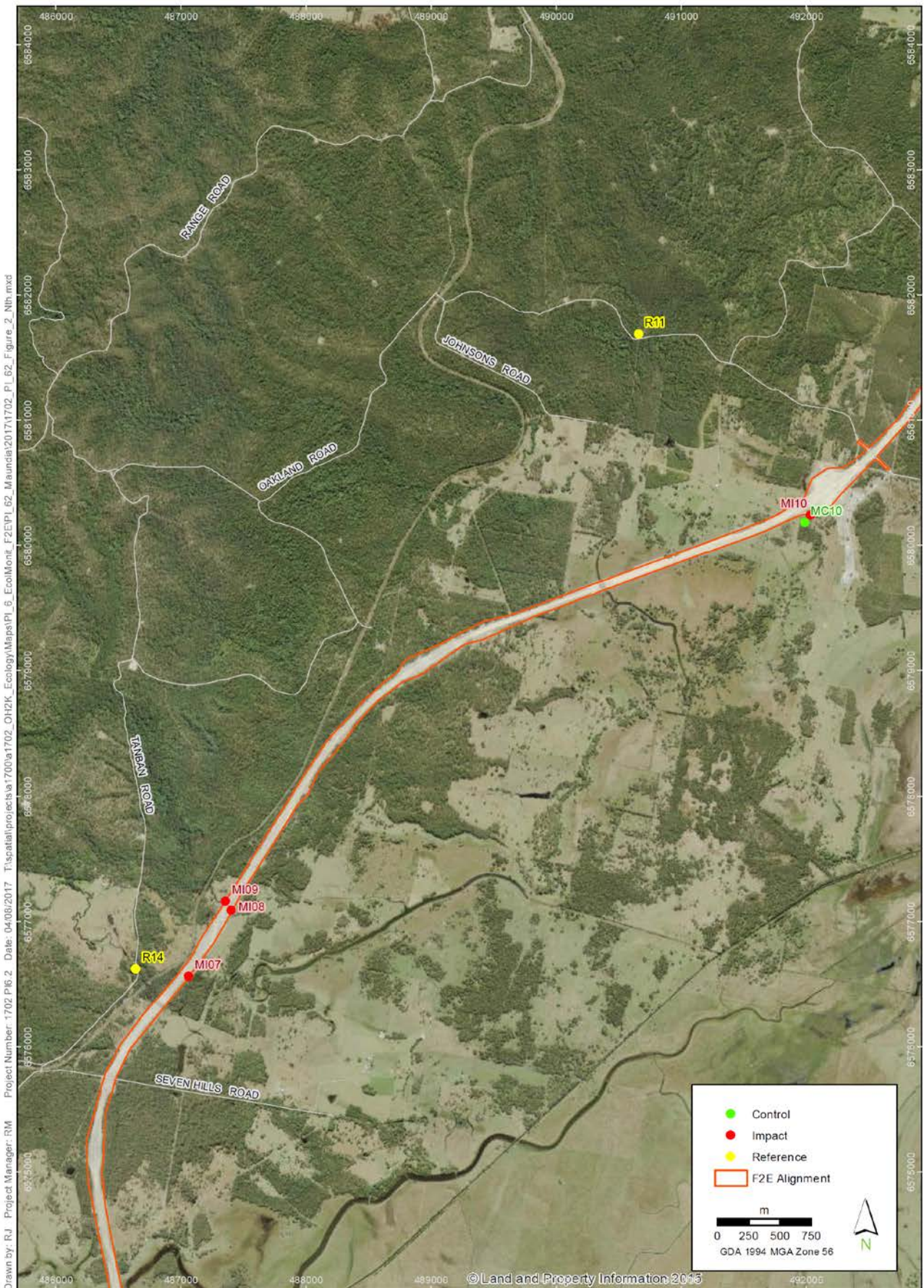
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F2E Maundia Monitoring Locations Dec 2016, Feb 2017, May 2017: Overview

Pacific Highway Upgrade: Frederickton to Eungai

FIGURE 1



F2E Maundia Monitoring Locations Dec 2016, Feb 2017, May 2017: Northern Section

Pacific Highway Upgrade: Frederickton to Eungai



F2E Maundia Monitoring Locations Dec 2016, Feb 2017, May 2017: Southern Section

Pacific Highway Upgrade: Frederickton to Eungai

Annex A. 2016/2017 monitoring results

Site Name	Design	Chainage (Location)	Easting	Northing	Inspection Date			Maundia present			% Maundia cover extent in 100 m ²			Water Depth (cm)			% Flowering/ Seeding			Recruitment (# individuals)		
					December 2016	February 2017	May 2017	December 2016	February 2017	May 2017	December 2016	February 2017	May 2017	December 2016	February 2017	May 2017	December 2016	February 2017	May 2017	December 2016	February 2017	May 2017
MI01	impact	15360 (East)	487671	6568746	08/12/2016	15/02/2017	18/05/2017	Y	Y	Y	0.9	1.1	2.1	0-50	0-0.3	30-60	18	0	0	0	0	0
MC01	control	100 m downstream	487723	6568775	08/12/2016	15/02/2017	18/05/2017	Y	Y	Y	7.2	20.0	10.0	0-20	0	10-20	4	0	0	5	0	0
MI02	impact	17360 (East)	486650	6570499	08/12/2016	15/02/2017	18/05/2017	Y	Y	Y	27.6	19.0	32.6	0	0	10-20	1	0	0	0	0	0
MC02	control	50 m downstream	486727	6570489	08/12/2016	15/02/2017	18/05/2017	Y	Y	Y	12.6	5.4	11.2	0	0	0	2	0	0	0	23	0

Site Name	Design	Chainage (Location)	Easting	Northing	Inspection Date			Maundia present			% Maundia cover extent in 100 m ²			Water Depth (cm)			% Flowering/ Seeding			Recruitment (# individuals)		
					December 2016	February 2017	May 2017	December 2016	February 2017	May 2017	December 2016	February 2017	May 2017	December 2016	February 2017	May 2017	December 2016	February 2017	May 2017	December 2016	February 2017	May 2017
MI03E	impact	19200 (East)	486546	6572155	06/12/2016	14/02/2017	18/05/2017	Y	N	Y	0.2	0	2.7	0	0	0	0	0	0	0	0	15
MI03W	impact	19200 (West)	486461	6572090	06/12/2016	14/02/2017	16/05/2017	Y	Y	Y	3.0	0.2	18.8	0	0	10-20	0	0	0	0	0	107
MI04	impact	19950 (West)	486484	6572948	06/12/2016	15/02/2017	16/05/2017	Y	Y	Y	35.0	6	2.1	0-10	0	20-50	1	1	0	65	66	0
MI05	impact	20100 (East)	496604	6573123	08/12/2016	15/02/2017	18/05/2017	Y	N	N	0.1	0	0	0-1	0	0	0	0	0	0	0	0







Site Name	Design	Chainage (Location)	Easting	Northing	Inspection Date			Maundia present			% Maundia cover extent in 100 m ²			Water Depth (cm)			% Flowering/ Seeding			Recruitment (# individuals)		
					December 2016	February 2017	May 2017	December 2016	February 2017	May 2017	December 2016	February 2017	May 2017	December 2016	February 2017	May 2017	December 2016	February 2017	May 2017	December 2016	February 2017	May 2017
MC05	control	100 m downstream	496604	6573123	08/12/2016	15/02/2017	18/05/2017	Y	Y	Y	16.8	0.2	0.2	0-30	0	20-50	17	0	0	167	1	0
MI06	impact	20850 (East)	486548	6573914	07/12/2016	14/02/2017	16/05/2017	N	N	N	0	0	0	0	0	0	0	0	0	0	0	0
MC06	control	100 m downstream	486564	6573899	07/12/2016	14/02/2017	16/05/2017	Y	N	N	0.1	0	0	0	0	0	0	0	0	0	0	0
MI07	impact	23800 (East)	487058	6576563	05/12/2016	14/02/2017	18/05/2017	N	N	N	0	0	0	0	0	0	0	0	0	0	0	0







Site Name	Design	Chainage (Location)	Easting	Northing	Inspection Date			Maundia present			% Maundia cover extent in 100 m ²			Water Depth (cm)			% Flowering/ Seeding			Recruitment (# individuals)		
					December 2016	February 2017	May 2017	December 2016	February 2017	May 2017	December 2016	February 2017	May 2017	December 2016	February 2017	May 2017	December 2016	February 2017	May 2017	December 2016	February 2017	May 2017
MI08	impact	24450 (West)	487403	6577089	07/12/2016	14/02/2017	18/05/2017	Y	N	Y	2.0	0	0.1	0	0	10-30	35.5	0	0	0	0	0
MI09	impact	24450 (West)	487352	6577162	07/12/2016	14/02/2017	17/05/2017	Y	Y	Y	4.8	0.4	2.7	30	0	20	31.8	22.2	0	0	0	0
MI10	impact	30275 (South)	492027	6580246	06/12/2016	14/02/2017	17/05/2017	N	N	N	0	0	0	0	0	0	0	0	0	0	0	0
MC10	control	50 – 100 m downstream	491981	6580190	06/12/2016	14/02/2017	17/05/2017	Y	Y	Y	1.8	1.1	7.7	0	0	10	0	0	0	13	15	0






Site Name	Design	Chainage (Location)	Easting	Northing	Inspection Date			Maundia present			% Maundia cover extent in 100 m ²			Water Depth (cm)			% Flowering/ Seeding			Recruitment (# individuals)		
					December 2016	February 2017	May 2017	December 2016	February 2017	May 2017	December 2016	February 2017	May 2017	December 2016	February 2017	May 2017	December 2016	February 2017	May 2017	December 2016	February 2017	May 2017
R11	reference	Cols Causeway	490652	6581695	06/12/2016	15/02/2017	16/05/2017	Y	Y	Y	26.2	1.2	2.7	0-10	0	10-50	0.2	0	0	19	7	0
R12	reference	Collombatti-Tamban Road	484393	6571941	06/12/2017	15/02/2017	16/05/2017	Y	Y	Y	10.0	2.3	0.8	0-5	0	20-40	0	0	0	19	0	0
R14	reference	Tamban Road	486641	6576627	06/12/2016	15/02/2017	16/05/2017	Y	N	Y	0.2	0	0.8	0	0	5-10	0	0	0	0	0	0

Y = Yes; N = No







Annex B. 2016/2017 Photo Monitoring







Site ID	December 2016	February 2017	May 2017
MI01			
MC01			

Site ID	December 2016	February 2017	May 2017
MI02			
MC02			







Site ID	December 2016	February 2017	May 2017
MI03E			
MI03W			






Site ID	December 2016	February 2017	May 2017
MI04			
MI05			

Site ID	December 2016	February 2017	May 2017
MC05			
MI06			

Site ID	December 2016	February 2017	May 2017
MC06			
MI07			

Site ID	December 2016	February 2017	May 2017
MI08			
MI09			

Site ID	December 2016	February 2017	May 2017
MI10			
MC10			

Site ID	December 2016	February 2017	May 2017
R11			
R12			

Site ID	December 2016	February 2017	May 2017
R14			

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Appendix C Green-thighed Frog Ponds



Green-thighed Frog Monitoring 2016/2017

Habitat Protection and Breeding Ponds

Frederickton to Eungai Pacific Highway Upgrade

Prepared for Roads and Maritime Services

9 August 2017

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Cover photograph: Green-thighed Frog located at Collombatti Reference Site (Photo: F. Lemckert)

Executive summary

Context

This report documents the first of three monitoring events for the Green-thighed Frog Breeding Ponds established as compensatory habitat, and the first of two monitoring events for Habitat Protection – Green-thighed Frog Breeding Sites, as required by the Frederickton to Eungai (F2E) Ecological Monitoring Program (EMP, RMS 2016).

The Green-thighed Frog (*Litoria brevipalmata*) was one threatened species identified as requiring mitigation and monitoring through the course of the Projects' construction and operational period. As outlined within the approved EMP (RMS 2016), monitoring for this species involves both Habitat Protection – Green-thighed Frog Breeding Sites monitoring and Green-thighed Frog Breeding Pond monitoring.

Aims

The aims of this report are to summarise the methods and results of the 2016/2017 monitoring and provide an overall discussion to determine if performance measures have been met, as per the EMP (RMS 2016).

Methods

Surveys were undertaken in accordance with the EMP (RMS 2016). Stage 1 surveys were triggered by sufficient rainfall (EMP 2016) and involved a 30 minute nocturnal active search at the Collombatti reference site, at Hills Lane, and at each of the constructed pond sites (19) as well as a peripheral habitat search. Stage 2 surveys were undertaken as required, 39 (Hills Lane) and 42-43 (Collombatti reference and breeding ponds) days after Stage 1 surveys. Stage 2 surveys involved a 20 minute active search of the ponds and adjacent vegetation and dip-netting of ponds for tadpoles. Pond depth was recorded, presence of fish and predatory larvae noted, and a photo was taken from a designated reference point.

Key results

No Green-thighed Frogs or tadpoles were recorded during Stage 1 or Stage 2 surveys at any of the constructed pond sites or at the Hills Lane breeding site. One Green-thighed Frog was identified during Stage 1 surveys at the Collombatti reference site.

Thirteen of the nineteen monitored ponds were dry at Stage 2 surveys.

Conclusions

The three performance indicators of success were not met for the 2016/2017 monitoring period based on the absence of the stages of Green-thighed Frogs (tadpoles, metamorphs, juveniles or adults) from the breeding pond sites and Hills Lane breeding site. Two of the three performance indicators of unsuccessful mitigation have been met, owing to the absence of Green-thighed Frogs from monitoring areas and the majority of ponds not holding water for long enough.

Management implications

A number of identified potential problems and contingency measures presented in the EMP (RMS 2016) are considered relevant due to the absence of Green-thighed Frogs from monitoring sites and the constructed ponds not holding water for long enough. Due to these outcomes, it is recommended that Roads and Maritime Services pursue discussions with the EPA to determine appropriate measures for the continued monitoring and any corrective actions needed.

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1. Introduction

1.1 Context

As part of Frederickton to Eungai (F2E) Pacific Highway Upgrade Project (the Project), Roads and Maritime Services (Roads and Maritime) have implemented an Ecological Monitoring Program (EMP) in accordance with the Minister for Planning's Condition of Approval (MCoA) No. 3.1. This Ecological Monitoring Program (RMS 2016) (hereafter referred to as EMP) combines the approval conditions provided within the Ministers Conditions of Approval (MCoA) and Statement of Commitments (SoC), and defines the mitigation and offsetting requirements for threatened species and ecological communities impacted by the Project.

The Green-thighed Frog (*Litoria brevipalmata*) was one threatened species identified as requiring mitigation and monitoring through the course of the Projects' construction and operational period. As outlined within the approved EMP, monitoring of this species involves both Habitat Protection – Green-thighed Frog Breeding Sites monitoring and Green-thighed Frog Breeding Pond monitoring (monitoring of specially constructed breeding ponds).

1.1.1 Legal Status

The Green-thighed Frog is listed as vulnerable under the NSW *Threatened Species Conservation Act 1995* (TSC Act). Monitoring of the species is required under the Project's approval.

1.1.2 Monitoring framework

The approved EMP states the following regarding monitoring:

- For Habitat Protection – Green-thighed Frog Breeding Sites: *"Monitoring will only be undertaken if construction works extend into the identified known Green-thighed Frog breeding sites"*. This condition has been triggered at the Hills Lane breeding site.
- For Green-thighed Frog Breeding Ponds: *"Monitoring will be undertaken on three occasions commencing in 2015 with each event at least 10-12 months apart but ultimately dependant on rainfall."* It is noted that the required rainfall did not occur during the specified monitoring period in 2015/2016 (RMS 2017), as such monitoring commenced in summer 2016/2017.

This report presents the first monitoring event for both Habitat Protection – Green-thighed Frog Breeding Sites and Green-thighed Frog Breeding Ponds.

1.1.3 Baseline data

The EMP provides the following background data for Green-thighed Frog Breeding Ponds:

"Targeted surveys for the Green-thighed Frog in 2005 are considered the baseline data for this ecological monitoring program (Lewis 2005). These surveys identified Green-thighed Frogs calling in the area of the proposed frog pond locations at:

- *Ch. 22800 where 4-5 males were heard and observed, however, follow up surveys to determine the success of this breeding event found no evidence of tadpoles, metamorphs nor juvenile frogs.*
- *Ch. 26100 where more than a 100 Green-thighed Frogs were recorded with follow up surveys identifying numerous metamorphs and juvenile frogs to confirm a successful breeding event.*
- *Ch. 34000 where male frogs have been recorded during general spotlight surveys and area suspected of breeding nearby (i.e. < 500 m)."*

In relation to Habitat Protection – Green-thighed Frog Breeding Sites, the EMP refers to a number of suitable breeding sites within and adjacent to the Project. However, monitoring at these sites was to be

undertaken only if construction works extended into any of these identified breeding sites. This has become relevant for a single site, where back filling of a dam near Hills Lane has triggered the need for monitoring of the nearby breeding site that adjoins Hills Lane. The Hills Lane site was successfully used as a breeding site in 2005 (RMS 2016).

1.1.4 Purpose of this Report

This report complies with the monitoring requirements described within the approved EMP and details the findings obtained from the first of three monitoring events to be completed for the Green-thighed Frog Breeding Ponds and the first of two monitoring events for Habitat Protection – Green-thighed Frog Breeding Sites.

The aims of this report are to summarise the methods and results of the 2016/2017 monitoring and provide an overall discussion of all monitoring events and determine if performance measures have been met, as per the EMP.

1.2 Performance measures

The approved EMP specifies the performance indicators for the Green-thighed Frog Breeding Ponds and the Habitat Protection – Green-thighed Frog Breeding Sites monitoring. These are listed below in Table 1.

Table 1: Performance indicators

	GThF BP	HP GThF
Performance indicators of success		
Continued presence of Green-thighed Frog at Sites 1, 2 and 3 and Hills Lane.	✓	✓
Green-thighed Frogs calling from the edge of the constructed ponds.	✓	
The presence of tadpoles, juveniles or metamorphs during follow up surveys.	✓	✓
Signs of the mitigation being unsuccessful		
Absence of Green-thighed Frogs from the area (GThF BP).	✓	✓
Absence of Green-thighed Frogs from the area that cannot be attributed to environmental factors (HP GThF)		
Ponds not holding water for a sufficient time to enable tadpoles to reach metamorphosis.	✓	
Ponds holding water for too long and representing unsuitable habitat (i.e. permanent versus ephemeral).	✓	

GThF BP = Green-thighed Frog Breeding Ponds; HP GThF = Habitat Protection - Green-thighed Frog Breeding Sites.

1.3 Monitoring timing

The EMP specifies that monitoring is to be undertaken on three occasions commencing, at its earliest, in 2015 with each event at least 10-12 months apart but ultimately dependant on rainfall events. One of these monitoring events is to occur during the operational phase of the project (i.e. Year 4/5). Monitoring was only to commence once the vegetation on the edges of the constructed ponds is considered sufficient (>20% groundcover).

The current monitoring took place in March 2017. As per the EMP, the next monitoring event should take place from January 2018, however due to the dependence of this species on very specific rainfall events, surveys may be undertaken prior to this if weather conditions are considered suitable by the frog expert (Dr

F. Lemckert). This complies with the EMP that states that survey timing is ultimately dependant on rainfall events.

1.4 Reporting

Annual reporting of monitoring results will outline:

- A description of the monitoring methodology employed.
- Results of the monitoring surveys.
- A discussion of the results, including how the results compare against key performance criteria.
- The need for any corrective actions/contingency measures and any general recommendations.

All reports prepared under the EMP will be submitted to the Director General of the NSW Department of Planning and Environment and the NSW Environment Protection Authority (EPA).

1.5 Limitations

The following limitations to the monitoring procedure were encountered:

- A definitive statement as to the fulfilment of performance indicators relating to ponds drying too soon or holding water for too long cannot be made for some or all of the ponds, due to the EMP requiring Stage 2 surveys to be undertaken 30 – 50 days after Stage 1. As such, data concerning the presence of water or water retention beyond the timing of the Stage 2 surveys is not available.

2. Methods

2.1 Monitoring sites

Green-thighed Frog Breeding Ponds were established as compensatory habitat within the areas identified in the baseline data (RMS 2016). The site locations are shown in Figure 1, with details provided in Table 2. Four to five ponds are located at each site. These sites correspond to the proposed pond locations as indicated. The Collombatti site was used as the reference site. As site ponds are located close enough to be within GPS error, it was determined that each pond should be marked with a star picket and labelled with the pond identification number for future monitoring events.

At Site 1, four breeding ponds, as opposed to five, were constructed and monitored due to the availability of natural habitat in the area and to reduce the need for additional clearing. The EMP states: *“At this location, an area of retained suitable habitat will be monitored, in addition to the four constructed ponds. This location will be selected during the first monitoring event”*. No Green-thighed Frogs were recorded in adjacent habitat during the current monitoring event, as such the general area will be monitored in future monitoring events and a specific site nominated if and when Green-thighed Frogs are identified.

At Site 2, five ponds to the east of the carriageway were monitored during the 2016/2017 surveys. The remaining ponds have been completed and will be monitored during the 2017/2018 surveys.

At Site 3, a number of ponds were constructed to the east and to the west of the carriageway. All of the available ponds were assessed and the five most suitable (based on results) either side of the carriageway were retained for the 2017/2018 monitoring program.

Table 2: Survey sites

Site Name (map ID)	Proposed frog pond sites (EMP)
Collombatti Reference (Ref)	A site near Collombatti School within State Forest (Easting: 483825 Northing: 6573800) was nominated and retained as the reference site.
1E	Ch. 22800: A total of 4 ponds were monitored as well as adjacent habitat.
2E	Ch. 26100: A total of 10 ponds are to be monitored, however 5 (Site 2E) were monitored in the current surveys.
2W	
3E	Ch. 34000: A total of 10 ponds were monitored, 5 on the eastern side of the carriageway and 5 on the western side.
3W	

2.2 Survey method

The survey method described within the EMP was employed for all surveys (Breeding Ponds and Habitat Protection site) and is provided below.

Monitoring of the constructed breeding ponds would be undertaken on a rainfall event basis either after:

- the 24 hr rainfall totals exceed 75 mm, or
- a cumulative total of 150 mm over a 72 hour period, or
- an alternative rainfall event deemed suitable by the ecologist.

Rainfall events would be monitored for either one or more of the three weather stations installed by the Contractor and/or the Bureau of Meteorology (BOM) website and specifically the Collombatti location (Station No. 599037). Surveys would be performed using a two stage process outlined below.

a) Stage 1 – Determining Presence and Breeding Activity

Once the rainfall trigger values detailed above occur in the area the reference site would be visited to determine the extent of Green-thighed Frog activity. The constructed ponds and their surrounds would also be surveyed.

The survey would comprise a 30 minute nocturnal active search at each of the breeding pond areas (sites) using a hand held spotlight. Peripheral habitats (i.e. <100 m) would also be surveyed at this time. Upon the completion of Stage 1 surveys the next stage would be implemented.

b) Stage 2 – Determining the Success of the Breeding Event

All sites would be subject to follow-up surveys between 30-50 days after the initial census to assess the outcome of the breeding event. This follow up survey will comprise:

- A 20 minute active search for metamorphs and juvenile frogs around the pond edge and vegetation immediately adjacent to the pond (i.e. <10 m).
- Dip-netting of the constructed pond and subsequent tadpole identification. Specific attention will be given toward identifying the presence of fish (both native and exotic) along with predatory invertebrates such as dytiscid beetle adults and larvae.
- The depth of the ponds would be measured from the permanently installed water staff, or alternative method.
- Photo taken from a designated reference point.

2.3 Analysis of data

Monitoring results will be analysed in accordance with the performance indicators specified within the EMP. In the case of the Green-thighed Frog, performance measures are based on presence/absence results and pond habitat and do not require statistical comparison between survey events. As such, statistical analysis between survey events is not required.

3. Results

Results of Stage 1 and Stage 2 monitoring for all sites are provided in Annex 1 and photo monitoring in Annex 2.

a) Stage 1 – Determining Presence and Breeding Activity

Suitable rainfall, as specified within the EMP, did not occur until March 2017. As such, Stage 1 surveys were undertaken on the 16th, 17th (Collombatti reference and breeding ponds) and 20th (Hills Lane) March 2017 when rainfall was deemed suitable by the Project Ecologist. Rainfall at the sites in the previous 24 hours before these surveys ranged from 105 mm to 134 mm and air temperatures ranged from 20°C to 23°C. This rainfall was within the recommended range stated in the EMP: 24 hr rainfall totals exceed 75 mm, or a cumulative total of 150 mm over a 72 hour period.

Nocturnal active searches

No Green-thighed Frogs were heard calling at any pond site during Stage 1 surveys, however one non-calling Green-thighed Frog was identified at the Collombatti reference site within 10 m of water.

A number of other frog species were heard calling at the Collombatti reference site, Site 2, Site 3 and Hills Lane. No frogs were heard calling or identified calling at the ponds created at Site 1. Other species identified include the Great Barred Frog (*Mixophyes fasciolatus*), Striped Marsh Frog (*Limnodynastes peronii*), Common Froglet (*Crinia signifera*), Dusky Toadlet (*Uperoleia fusca*), Whirring Tree Frog (*Litoria revelata*) and Eastern Dwarf Tree Frog (*Litoria fallax*).

Pond depth at Stage 1

All ponds contained 10 – 30 cm of water during Stage 1 surveys.

b) Stage 2 – Determining the Success of the Breeding Event

Stage 2 surveys were undertaken on the 28th April 2017, 39 (Hills Lane) and 42-43 (Collombatti reference and breeding ponds) days after Stage 1 surveys.

Active searches and dip-netting

A number of tadpoles were caught at the Collombatti reference site and Hills Lane breeding site, however only a single tadpole was collected at Site 2 and Site 3. The tadpoles were inspected by Dr F. Lemckert to determine if they were potentially Green-thighed Frogs. None of the tadpoles at the impact sites were Green-thighed Frog tadpoles as they were either not hylid tadpoles or were not the correct type of hylid tadpoles (based on behaviour and morphology). One tadpole collected from the Collombatti reference site was retained as a potential Green-thighed Frog tadpole, but further investigation identified it as Whirring Tree Frog.

Gambusia (*Gambusia holbrooki*) were identified to be present at the Collombatti reference site and Hills Lane breeding site.

Pond depth at Stage 2

During the Stage 2 surveys water levels in the constructed ponds were as follows:

- Site 1 - two of the four constructed ponds held water (15 cm and 10 cm deep)
- Site 2 - two of the five constructed ponds held water (20 cm and 25 cm deep)
- Site 3 - two of the ten constructed ponds held water (25 cm and 15 cm).

4. Discussion

4.1 Performance measures

A discussion of the summer 2017 monitoring results in relation to the performance measures detailed in the EMP is provided in Table 3 and Table 4.

Table 3: Performance indicators of success

Performance indicators of success	GThF BP	HP GThF
Continued presence of Green-thighed Frog at Sites 1, 2 and 3 and Hills Lane breeding site.	This performance indicator has not been met. Green-thighed Frogs were not observed at any of the sites.	
Green-thighed Frogs calling from the edge of the constructed ponds.	This performance indicator has not been met. Green-thighed Frogs were not heard calling at any of the sites containing constructed ponds.	NA
The presence of tadpoles, juveniles or metamorphs during follow up surveys.	This performance indicator has not been met. Green-thighed Frog tadpoles, juveniles or metamorphs were not observed during follow up surveys.	

GThF BP = Green-thighed Frog Breeding Ponds; HP GThF = Habitat Protection - Green-thighed Frog Breeding Sites; NA = not applicable

Table 4: Signs of the mitigation being unsuccessful

Performance indicators of unsuccessful mitigation	GThF BP	HP GThF
Absence of Green-thighed Frogs from the area.	This indicator of unsuccessful mitigation has been met. Green-thighed frogs were not detected in the area of constructed ponds.	NA
Absence of Green-thighed Frogs from the area that cannot be attributed to environmental factors.	NA	This indicator of unsuccessful mitigation has not been met. It is considered possible that Green-thighed Frogs were not recorded at Hills Lane breeding site due to environmental factors. Given that a single non-calling Green-thighed Frog was identified at the Collombatti reference site four days earlier it is possible that superfluous rainfall during and around the time of surveys may have provided opportunity for breeding at other times.
Ponds not holding water for a sufficient time to enable tadpoles to reach metamorphosis.	This indicator of unsuccessful mitigation has been met for at least 13 of the 19 monitored ponds. According to the EMP ponds should have a maximum depth of 400 mm and hold water for up to 60-80 days. Thirteen of the ponds were dry at Stage 2 surveys, undertaken 39 – 43 days after Stage 1	NA

Performance indicators of unsuccessful mitigation	GThF BP	HP GThF
	surveys. For the remaining 6 ponds that contained water during Stage 2 surveys, survey timing precludes a definitive statement as to whether or not ponds still contained water at 60 days.	
Ponds holding water for too long and representing unsuitable habitat (i.e. permanent versus ephemeral).	This indicator of unsuccessful mitigation has not been met for 13 of the 19 constructed ponds. A definitive statement as to the fulfilment of this performance indicator cannot be made for the remaining 6 of the 19 constructed ponds due to surveys requiring Stage 2 surveys to be undertaken 30 – 50 days after Stage 1. As such, data concerning the presence of water in these ponds after 80 days is not available.	NA

GThF BP = Green-thighed Frog Breeding Ponds; HP GThF = Habitat Protection - Green-thighed Frog Breeding Sites, NA = not applicable

5. Recommendations

5.1 Contingency Measures

The EMP lists potential problems and contingency measures for various components of the monitoring program. Those that are considered to be relevant to the Green-thighed Frog monitoring program are listed and discussed in Table 5.

Table 5: Contingency Measures

Potential Problem	Contingency Measure proposed in EMP	Discussion of proposed measure
Habitat Protection – Green-thighed Frog Breeding Sites (Hills Lane)		
Lack of communication between construction staff leading to damage or removal of known breeding site	Review the CEMP and site induction procedures	This contingency measure is not considered relevant.
Habitat not used by Green-thighed Frog	Survey adjacent areas to confirm frogs remain in the area	Green-thighed Frogs were not recorded at the Hills Lane site. This contingency measure is considered relevant.
Green-thighed Frog Breeding Ponds		
Ponds not used by Green-thighed frog	Survey adjacent areas to confirm frogs remain in area. Review/modify ponds to improve potential site suitability problems	Green-thighed Frogs were not recorded at the constructed ponds. This contingency measure is considered relevant.
Ponds not holding water long enough to enable breeding to succeed	Review/modify ponds either by placing a semi permeable layer or further excavation	The majority of constructed ponds were dry during Stage 2 surveys and therefore are considered as not holding water long enough (recommended up to 60-80 days). The survey timing does not permit comment on water levels beyond Stage 2 surveys. This contingency measure is considered relevant.
Ponds holding water for too long encouraging competition from non-target frog fauna	Improve drainage	The majority of constructed ponds were dry during Stage 2 surveys and therefore are considered as not holding water for too long (maximum 80 days). The survey timing does not permit comment on water levels beyond Stage 2 surveys. This contingency measure is not considered relevant.
Exotic fish species recorded in breeding ponds	Modify pond to ensure it dries out	Exotic fish species were not detected in constructed ponds. This contingency measure is not considered relevant.

5.2 Recommendations

Performance indicators of success were not met during the 2017 monitoring of the Habitat Protection – Green-thighed Frog Breeding Sites and Green-thighed Frog Breeding Ponds.

Performance measures of unsuccessful mitigation have been met.

Due to these outcomes, it is recommended that the Roads and Maritime Services pursue discussions with the EPA to determine appropriate measures for continued monitoring and any corrective actions needed.

As this report addresses the first monitoring event for both Habitat Protection – Green-thighed Frog Breeding Sites and Green-thighed Frog Breeding Ponds, the following recommendations/considerations are provided to address the proposed contingency measures as identified in the EMP, in an effort to maximise the likelihood that performance measures may be achieved in the future.

Considerations

While specific recommendations have not been made, the following considerations should be taken into account in any interim discussions with the EPA and for the development of monitoring programs and compensatory habitat for this species.

Pond specifications: Install water staff with graduated water depth indicators in all ponds to facilitate water depth estimations.

Dry ponds: Consider laying a semi-permeable layer to improve water retention. Consider increasing the size of these ponds to increase the volume and likely hydroperiod. Recommended dimensions: 10 m x 5 m, 50 – 100 cm deep. These recommended dimensions are based on the research of Dr David Ledlin (Ledlin 1997).

Additional surveys: Additional surveys in habitat that is adjacent to monitoring sites and that is deemed suitable for Green-thighed Frogs by the project ecologist would assist in determining the continued presence and activity of the species in the area.

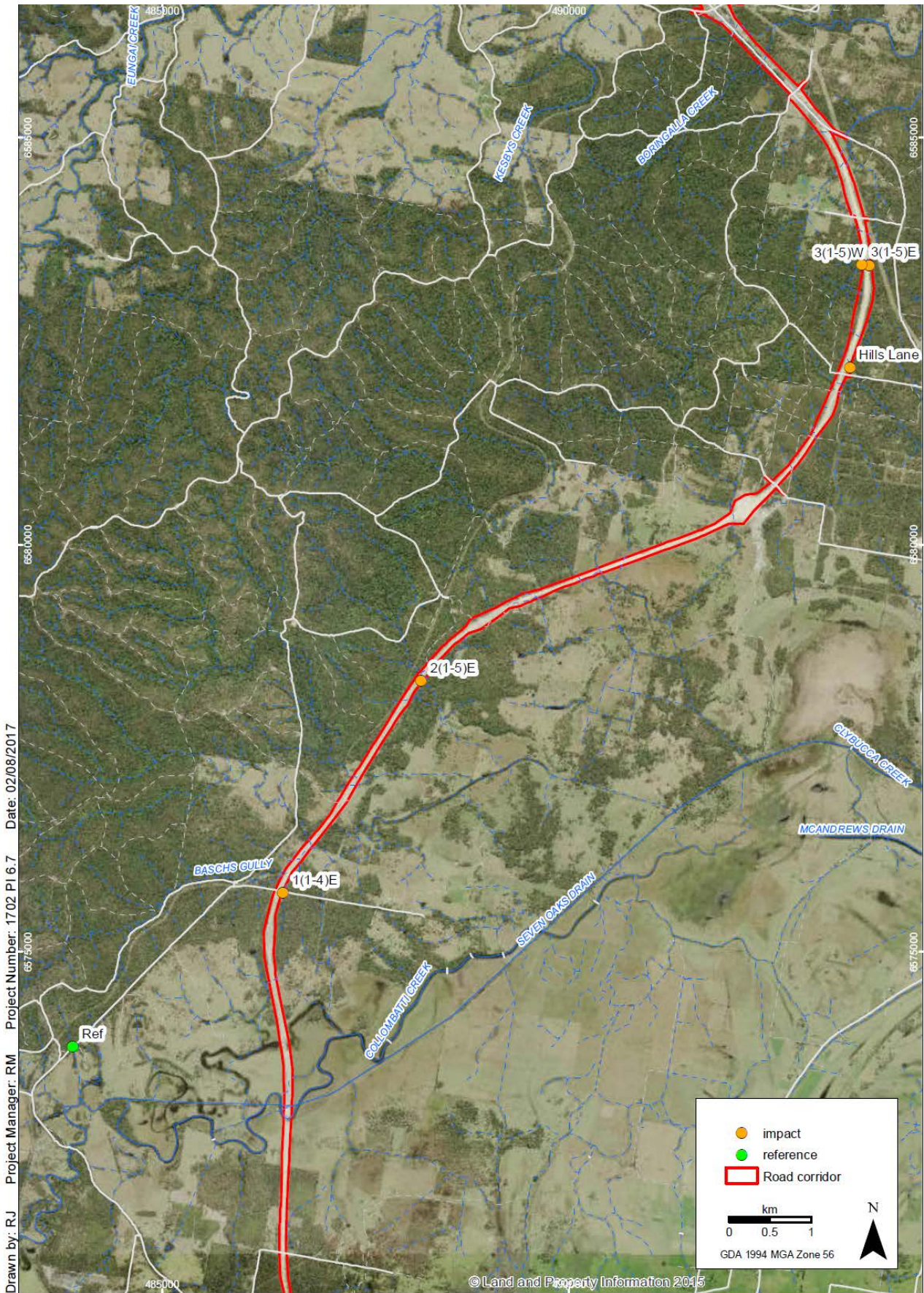
Survey timing: Consider flexibility in survey timing to permit surveys to occur at a time deemed suitable by the frog expert. This will minimise the chance of missing a breeding event during rainfall episodes that may fall under the current rainfall threshold.

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Green-thighed Frog monitoring sites
Pacific Highway Upgrade Frederickton to Eungai

FIGURE 1

Imagery: (c) LPI 2014-09-18

Annex 1. 2016/2017 Results

Stage 1 Results






Site Name	Date	Time	GTF Observed	GTF Calling	Other Species	Rainfall mm (24hrs)	Air Temp (°C)	Humidity (%)	Wind	Cloud Cover (%)
Hills Lane	20/03/2017	20:30	0	0	Whirring Tree Frog, Common Froglet, Red-backed Toadlet, Striped Marsh Frog, Great Barred Frog.	104.6	20	89	0	80
Reference	16/03/2017	0:40	1	0	Great Barred Frog, Striped Marsh Frog, Common Froglet, Dusky Toadlet, Whirring Tree Frog.	124.2	21.3	82	0	10
1 P1-4 and habitat	17/03/2017	1:17	0	0		133.8	22.7	83	0	5
2E P1-5	16/03/2017	24:00	0	0	Whirring Tree Frog, Common Froglet, Striped Marsh Frog, Dusky Toadlet, Great Barred Frog.	133.8	23.3	79	0	20
3E P1-5	16/03/2016	22:52	0	0	Dwarf Tree Frog, Common Froglet, Striped Marsh Frog, Great Barred Frog.	133.8	22.7	83	0	40
3W P1-5	16/03/2016	23:25	0	0		133.8	22.7	83	0	40






Stage 2 Results

Site	MAP ID	Date	Water Depth (cm)	No. GTF (juv)	No. of tadpoles caught	Tadpoles identified	Presence of Fish	Predatory Invertebrates
Collombatti Reference	Ref	28/04/2017	30	0	22	<i>Limnodynastes sp.</i> , likely <i>peronii</i> . <i>Litoria revelata</i> .	Gambusia	
Hills Lane	Hills Lane	28/04/2017	0					
			40	0	10	<i>Limnodynastes sp.</i>	Gambusia	
1	1(1-5)E	28/04/2017	15	0	0			
	1(1-5)E		10	0	0			
	1(1-5)E		0	0	0			
	1(1-5)E		0	0	0			
1(habitat)	NA		0	0	0			
2E	2(1-5)E	28/04/2017	0	0	0			
	2(1-5)E		25	0	1	Probable Rocket Frog.		
	2(1-5)E		20	0	0			
	2(1-5)E		0	0	0			
	2(1-5)E		0	0	Tadpoles present Stage 1			
3W	3(1-5)W	28/04/2017	0	0	0			
	3(1-5)W		0	0	0			
	3(1-5)W		0	0	0			
	3(1-5)W		0	0	0			

Site	MAP ID	Date	Water Depth (cm)	No. GTF (juv)	No. of tadpoles caught	Tadpoles identified	Presence of Fish	Predatory Invertebrates
	3(1-5)W		0	0	0			
3E	3(1-5)E	28/04/2017	25	0	1	Tree frog species – but not Green-thighed Frog.		
	3(1-5)E		15	0	0			
	3(1-5)E		0	0	0			
	3(1-5)E		0	0	0			
	3(1-5)E		0	0	0			

Annex 2. 2016/2017 Photo Monitoring

Site	Pond 1	Pond 2	Pond 3	Pond 4	Pond 5
1					
2W					
3W				NA	NA

Site	Pond 1	Pond 2	Pond 3	Pond 4	Pond 5
3E					

NA = Photos not available

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Appendix D Nest Boxes



Nest Box Monitoring 2016/2017

Frederickton to Eungai Pacific Highway Upgrade

Prepared for Roads and Maritime Services

March 2018

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Cover photograph: Common Brushtail Possum (left) and Sugar Gliders (right) recorded during summer monitoring.

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Locations

Sydney
Central Coast
Illawarra
Armidale
Newcastle
Mudgee
Port Macquarie
Brisbane
Cairns

Executive summary

Context

This report documents the 2016/2017 monitoring period (summer and winter) for nest boxes, as required by the Frederickton to Eungai (F2E) Ecological Monitoring Program (EMP, RMS 2016).

Aims

The aims of this report are to summarise the methods and results of the summer and winter 2016/2017 monitoring and determine if performance measures have been met, as per the EMP.

Methods

In accordance with the EMP, a visual inspection of each nest box was undertaken in summer between the 12th and 20th December 2016 and in winter between the 30th June and 7th July 2017. Using a wireless camera attached to the end of an extendable pole the inside of each box was inspected for signs of use by fauna. Where a nest box was occupied the species was identified where possible. Unoccupied nest boxes were examined for signs of use, such as leaf litter and bark, well-formed nests, feathers, hair or scats. The condition of each box was examined and any deterioration or maintenance issues were noted. Whilst the majority of nest boxes were inspected using the wireless camera and extendable pole, those few that could not be reached were visually inspected on 1st March 2017 and 31st August 2017 by a qualified tree climber with an ecologist on site to collect the appropriate data.

Key results

There were a total of 250 nest boxes monitored in summer and 249 in winter during the 2016/2017 monitoring period. A total of 176 nest boxes in summer (70.4%) and 175 (70.3%) in winter were occupied or showed signs of use by vertebrate fauna, representing 10 different species. Of particular note was the detection of the Brush-tailed Phascogale, Squirrel Glider and the Yellow-bellied Glider, listed as vulnerable under the NSW *Threatened Species Conservation Act* (TSC Act). The current monitoring results showed an increase in nest box usage (occupation and signs of use) compared to the first 2014/2015 monitoring period.

Possum, small glider, and large glider boxes recorded use by their target species. All other nest box types have shown occupation or signs of use by non-target vertebrate fauna. Pest activity has increased during the current monitoring period compared to the previous monitoring period (2014/2015).

Maintenance issues were recorded for 13.6% of boxes in summer and 8.8% in winter.

Conclusions

The performance measures have been met in relation to nest box use by a wide range of native fauna and a low rate of use by exotic species. Less than 10% (8.8%) of boxes require maintenance following the latest monitoring event in winter 2017, therefore meeting the performance measure for reduced maintenance requirements. Design-specific use was met by four of the eight nest box types, with SG, LG, PO and SF boxes all recording use by target species and MB, PL, COSO and LFO boxes showing no signs of use by target fauna.

Management implications

The current recommendation is to continue monitoring as per the EMP. Maintenance should also be undertaken as required to address all maintenance issues recorded during 2016/2017 inspections.

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1. Introduction

1.1 Context

As part of the Frederickton to Eungai (F2E) Pacific Highway Upgrade Project (the Project), Roads and Maritime Services (Roads and Maritime) have implemented an Ecological Monitoring Program (hereafter referred to as the EMP, RMS 2016) in accordance with the Minister for Planning's Condition of Approval (MCoA) No. 3.1. This EMP combines the approval conditions provided within the Ministers Conditions of Approval (MCoA) and Statement of Commitments (SoC), and defines the mitigation and offsetting requirements for threatened species and ecological communities impacted by the Project.

1.1.1 Monitoring framework

The EMP states the following regarding nest box monitoring.

"It is proposed that monitoring would take place >6 months after the installation period (i.e. 2015) followed by a winter census to account for seasonal variation in the use of the nest boxes. It is proposed that annual monitoring and maintenance is undertaken thereafter and that a pre handover maintenance inspection is undertaken once construction is complete."

As per the EMP, monitoring of the installed nest boxes is to occur in summer and winter of 2015, 2017 and 2019. To date, these monitoring events have been reported as follows:

- Summer 2015, winter 2015: RMS 2015.
- Summer 2016, winter 2017: current report.

This report therefore represents the second of three required monitoring cycles.

1.1.2 Baseline data

The EMP provides the following information regarding baseline data for the nest box monitoring program:

"Baseline surveys performed in 2005 occur within or close to 10 of the 13 identified nest box zones in the Nest Box Plan of Management (Lewis 2012). The results of these earlier surveys provide a suitable baseline data set in which to assess performance measures on the types of fauna previously recorded in the project corridor."

1.1.3 Purpose of this Report

This report complies with the monitoring requirements described within the EMP and details the findings obtained from the second monitoring period.

The aims of this report are to summarise the methods and results of the summer 2016 and winter 2017 monitoring and determine if performance measures have been met, as per the EMP.

1.2 Performance measures

The EMP specifies the following performance indicators for the nest box monitoring program:

The performance of the nest box program would be assessed against the following parameters:

- Use of nest boxes by a wide range of native fauna.
- Use of nest boxes designed for specific species by those species (i.e. scansorial fauna nest box being used by these species).
- Low rates of exotic fauna using nest boxes.

- *Reduced maintenance requirements (<10% requiring attention).*

1.3 Monitoring timing

As per the EMP, monitoring is to be undertaken in summer and winter of 2015, 2017 and 2019.

1.4 Reporting

Annual reporting of monitoring results outline:

- A description of the monitoring methodology employed.
- Results of the monitoring surveys.
- A discussion of the results, including how the results compare against key performance criteria.
- The need for any corrective actions/contingency measures and any general recommendations.

All reports prepared under the EMP will be submitted to the Director General of the NSW Department of Planning and Environment and the NSW Environment Protection Authority (EPA).

2. Survey methods

2.1 Survey sites

The *Nest Box Plan of Management* (hereafter NBPoM, Lewis 2012) describes the number, type and distribution of nest boxes required to mitigate the loss of hollows, and the ongoing management of the nest boxes. The boxes were installed in two phases: 75% (220) of the nominated nest boxes from the NBPoM were installed prior to or during clearing to provide temporal refuge habitat. A post-clearing review was undertaken to determine the need for additional nest boxes. An additional 26 boxes were installed in December 2015, resulting in a total of 246 nest boxes. The 2015/2016 monitoring resulted in the installation of again a number of additional boxes due to loss or non-detection. In 2016/2017, a total of 250 nest boxes in summer and 249 in winter were located and monitored. A number of additional listed nest boxes were either not located or found to be double records of the same nest box (summer, 10 not found or duplicate and winter, 16 not found or duplicate). Nest boxes are distributed throughout thirteen zones (A to M), using a combination of different nest box types designed to target specific species (Table 1). The location of each zone is provided in Figure 1.

Table 1: Nest box type and target species.

Nest Box Design / Type	# insp 2016/2017		Target species
	Summer	Winter	
Microbats (MB)	32	32	Fluttering and direct flying species that use tree hollows
Small Gliders (SG)	45	45	Feather-tail Glider, Sugar Glider
Large Gliders (LG)	22	23	Squirrel Glider, Yellow-bellied Glider, Greater Glider
Scansorial Fauna (SF)	46	46	Antechinus, Brush-tailed Phascogale
Possoms (PO)	43	43	Common Brushtail Possum, Short-eared Possum, Common Ringtail Possum
Medium sized parrots (PL)	41	40	Lorikeets, Rosellas
Cockatoo/Small owl (COSO)	16	15	Black Cockatoos, King Parrot, Boobook Owl, Barn Owl
Large Forest Owls (LFO)	5	5	Masked Owl

2.2 Survey method

In accordance with the EMP, a visual inspection of each nest box was undertaken in summer between the 12th and 20th December 2016 and on the 1st March 2017 and in winter between the 30th June and the 7th July and on the 31st August 2017. The inspection of three nest boxes by a tree climber on the 1st March 2017 fell outside the summer season due to the limited availability of the tree climber. It is considered that this slight delay has not influenced the outcome of the surveys, two of these three boxes were occupied and one showed signs of use.

Using a wireless camera attached to the end of an extendable pole the inside of each box was inspected for signs of use by fauna. Where a nest box was occupied the species was identified where possible. Unoccupied nest boxes were examined for signs of use, such as leaf litter and bark, well-formed nests, feathers, hair or scats. The condition of each box was examined and any deterioration or maintenance issues were noted. The majority of nest boxes were inspected using the extendable pole and those that

could not be reached were visually inspected by a qualified tree climber with an ecologist on site to collect the appropriate data.

As required by the EMP, the following details were recorded for each nest box:

- Inspection date, weather conditions (rain, wind, cloud cover, ambient temperature) and time each nest box was inspected.
- Nest box identification number.
- If the nest box was occupied by native fauna, and if so, the species. If the nest box was not occupied by a native species, signs of use by native species, such as feathers, droppings, scats, hair or nesting material were recorded.
- If the nest box was occupied by a pest species such as European Bees, or Common Myna.
- Deterioration of the nest box and if any maintenance required.
- Any changes to the surrounding habitats, such as clearing or installation of wildlife crossing structures.

3. Results

Detailed field results for the summer and winter monitoring events are provided in Annex 1 and Annex 2.

3.1 Range of native fauna

Of the 250 (summer) and 249 (winter) inspected nest boxes, a substantial number were either occupied by native fauna (summer 40, 16.0%; winter 38, 15.3%) or showed additional signs of use (summer 136, 54.4%; winter 137, 55.0%). A total of 176 nest boxes in summer (70.4%) and 175 (70.3%) in winter were therefore occupied or showed signs of use by vertebrate fauna, representing 10 different species. Detailed results for each zone are provided in Annex 1.

Summer 2016 and winter 2017 recorded a total of 10 different species as follows:

- Mammals:
 - Arboreal mammals: Common Brushtail Possum (*Trichosurus vulpecula*), Yellow-bellied Glider (*Petaurus australis*), Sugar Glider (*Petaurus breviceps*), Common Ringtail Possum (*Pseudocheirus peregrinus*) and Squirrel Glider (*Petaurus norfolcensis*).
 - Scansorial mammals: Brush-tailed Phascogale (*Phascogale tapoatafa*)
- Birds: Dollarbird (*Eurystomus orientalis*) and Crimson Rosellas (*Platycercus elegans*)
- Reptiles: Lace Monitor (*Varanus varius*) and Green Tree Snake (*Dendrelaphis punctulata*).

Of particular note was the detection of the Brush-tailed Phascogale, Squirrel Glider and the Yellow-bellied Glider, all listed as vulnerable under the NSW *Threatened Species Conservation Act* (TSC Act).

Five of the eight target fauna groups (Table 1) were represented during the 2016/2017 monitoring period. These included: small gliders, large gliders, scansorial fauna, possums and medium sized parrots. Microbats, cockatoos/small owls and large forest owls were not recorded.

3.2 Design-specific use

Fauna observed to be occupying nest boxes at the time of monitoring have been grouped into the target fauna groups outlined in the NBPoM (as identified in Table 1) and their nest box use is provided in Table 2.

Boxes that recorded use by their target species included possum (PO), small glider (SG) and large glider (LG) boxes. Scansorial fauna (SF) boxes were used on a number of occasions, notably by small gliders, however scansorial fauna was recorded on a single occasion using a medium parrot (PL) box. Microbat boxes have not recorded any occupation by microbats in either monitoring period, however four boxes in the current monitoring event showed signs of use by other fauna with eucalypt leaves and white droppings observed. Medium parrot (PL) boxes were used by a range of non-target fauna, however representatives of the target fauna group were observed on only one occasion using a possum box. Cockatoo/small owl (COSO) and large forest owl (LF) boxes recorded use by non-target vertebrate fauna, however the target fauna were not recorded using any nest box type.

The three definite records of threatened species were observed using the following nest box types:

- Brush-tailed Phascogale: medium parrot.
- Squirrel Glider: scansorial fauna.
- Yellow-bellied Glider: large glider boxes and scansorial fauna.

Table 2: Nest box use by different fauna groups

Fauna group	SF	SG	LG	PO	MB	PL	COSO	LFO
Scansorial fauna						1		
Small Gliders	8	4	1			1		2
Large Gliders	1		2					
Glider sp.	2							
Possums	1	3	2	25		3	13	
Microbats								
Parrots/lorikeets				1				
Cockatoos								
Small Owls								
Large Forest Owls								
Other birds				1				
Reptiles		1	3			4		

3.2.1 Exotic fauna use

The NBPoM identifies non-native pest species that have the potential to utilise nest boxes, including, the European Bee (*Apis mellifera*), exotic birds including Common Myna (*Acridotheres tristis*) and Common Starling (*Sturnus vulgaris*), and termites and ants. These fauna are considered pests for the nest box program as they compete with native/target fauna for nesting resources, create nests/hives that exclude target fauna, and introduce maintenance and longevity issues.

Exotic birds were not recorded using the nest boxes. A total of 12 nest boxes (2.4%) showed signs of use by European Bees. Of the 12 nest boxes that showed signs of use by European Bees, 7 also showed signs of use or were occupied by vertebrate fauna and only one was observed to be fresh or active at the time of monitoring.

A total of 29 (11.6%) and 15 (6%) nest boxes, in summer and winter respectively, were either occupied or showed signs of occupation by non-native pest species. Pest fauna occupying these nest boxes included: European Bees (summer 7, 2.8%; winter 5, 2.0%), wasps (summer 5, 2.0%; winter 4, 1.6%) and ants (summer 17, 6.8%; winter 6, 2.4%).

3.3 Maintenance

Of the 250 (summer) and 249 (winter) nest boxes monitored, 34 (13.6%) require maintenance following the summer monitoring and 22 (8.8%) following the winter monitoring. Combining both the summer and winter inspections, a total of 45 (18.0%) nest boxes were recorded as requiring maintenance. Maintenance requirements include removal of pests and their nests, lid repair, total box replacement due to deterioration, vegetation trimming and box repositioning. The majority (35, 14%) of these maintenance records were for the removal of pests and their nests, with only 10 (4%) requiring structural attention. Maintenance requirements are provided in Annex 2 and will be undertaken in autumn 2018.

3.4 Comparison to baseline and previous surveys

3.4.2 Baseline survey comparison

Baseline surveys conducted by Lewis Ecological Surveys in 2005 (Lewis 2005) were used to create a summary of hollow dependent fauna recorded near or on the Project as presented in the NBPoM. Of the 62 hollow-dependent species recorded during baseline surveys, the 2016/2017 nest box monitoring recorded seven (one reptile, five mammals and one bird). It should be noted that 16 of the hollow-dependent species listed are bats and there has been no evidence of the bat boxes being used by target species in any survey. A further 29 are bird species of which one has been recorded and six frog species which are not targeted by nest box design. Two hollow-dependent species which were not detected in baseline surveys, the Green Tree Snake and Crimson Rosella, have been recorded.

3.4.3 Previous monitoring comparison

A total of 187 (summer) and 183 (winter) nest boxes were inspected during the 2014/2015 monitoring period (RMS 2015), recording a total of 10 species. Four of these species, *Antechinus sp.*, Northern Mallard (introduced species, *Anas platyrhynchos*), Diamond Python (*Morelia spilota spilota*) and Short-eared Brushtail Possum (*Trichosurus caninus*) were not recorded in 2016/2017. However 2016/2017 recorded four additional species, including two threatened species, not recorded in 2014/2015, the Dollarbird, Crimson Rosella, Yellow-bellied Glider and Squirrel Glider.

Table 3 lists the species recorded during the two monitoring periods. A total of 17 native species, representing five (small gliders, large gliders, scansorial fauna, possums and medium sized parrots) of the eight target fauna groups have been recorded occupying nest boxes. Microbats, cockatoos/small owls and large forest owls were not recorded during either monitoring event.

Rates of occupancy, signs of use, use by pest species, and maintenance requirements for the 2014/2015 and 2016/2017 monitoring periods are provided in Table 4. The occupation rate by native fauna increased during the current 2016/2017 monitoring period, as did the percentage of nest boxes showing signs of use by vertebrate fauna. Pest activity and maintenance requirements also increased during the current monitoring. All boxes inspected were reported to be in good condition for the 2014/2015 monitoring period.

Table 3: Species recorded in 2014/2015 and 2016/2017

Target group	Species	2014/2015	2016/2017
Scansorial fauna	<i>Antechinus</i> sp.	Yes	
	Brush-tailed Phascogale*	Yes	Yes
Small Gliders	Sugar Glider	Yes	Yes
	Squirrel Glider*		Yes
Large Gliders	Yellow-bellied Glider*		Yes
Possums	Brushtail Possum	Yes	Yes
	Ringtail Possum	Yes	Yes
	Short-eared Brushtail Possum	Yes	
Micro-bats			
Parrots/lorikeets	Crimson Rosella		Yes
Cockatoos/ Small Owls			
Large Forest Owls			
Other birds	Northern Mallard^	Yes	
	Dollarbird		Yes
Reptiles	Green Tree Snake	Yes	Yes
	Diamond Python	Yes	
	Lace Monitor	Yes	Yes

* = Threatened species; ^ = introduced species

Table 4: Comparison of nest box monitoring data between 2014/2015 and 2016/2017

Nest Box Monitoring	2014/2015		2016/2017	
	Summer	Winter	Summer	Winter
Occupation by native fauna %	10.6	11.5	16.1	15.3
Signs of use %	36.4	23.0	54.6	54.8
Pest activity %	8.5	1.1	11.2	6.0
Requiring maintenance %	0	1.6	13.6	8.8

4. Discussion

4.1 Performance measures

A summary of the summer and winter 2016/2017 survey results in relation to the performance measures is provided in Table 5 .

Table 5: Performance measures

Performance measures	Discussion
Use of nest boxes by a wide range of native fauna.	<p>This performance measure has been met for this monitoring event.</p> <p>A “wide range” is not defined by the EMP, as such the “range of native fauna” considered here has been related to the target fauna groups, and has considered observation of species representing >50% of the target groups as a “wide range”. Ten different species were recorded occupying the nest boxes during the 2016/2017 summer and winter monitoring and a total of 17 native species have been recorded over the two monitoring periods. Representatives from five of the eight target fauna groups were recorded. Microbats, owls and cockatoos have not been recorded during any monitoring event.</p>
Use of nest boxes designed for specific species by those species (i.e. scansorial fauna nest box being used by these species).	<p>This performance measure has been met by 4 of the 8 box types.</p> <p>Nest box types SG, LG, PO all recorded use by target fauna. SF boxes were not occupied by target fauna in the current monitoring period, however these were occupied by target fauna in 2014/2015. Nest box types MB, PL, COSO and LFO did not show signs of use by target fauna. The target fauna of these boxes were not recorded using any nest box type, with the exception of a Crimson Rosella record from a PO box. Additional monitoring events are required to determine either the success of these box types or the need to review the use of these nest box types as compensatory habitat.</p>
Low rates* of exotic fauna using nest boxes.	<p>This performance measure has been met.</p> <p>Exotic birds were not recorded using the nest boxes. A total of 7 (2.8%) and 5 (2.0%) nest boxes, in summer and winter respectively, were either occupied or showed signs of occupation by European Bees.</p>
Reduced maintenance requirements (<10% requiring attention).	<p>This performance measure has been met.</p> <p>Forty-five boxes (18%) were recorded as requiring maintenance during winter and summer inspections. The majority (35, 14%) of these maintenance records were for the removal of pests and their nests, with only 10 (4%) requiring structural attention. However, less than 10% (8.8%) of boxes were recorded as requiring maintenance following the most recent monitoring event in winter 2017, indicating that some boxes that had been occupied by pest species during summer were no longer occupied.</p>

*= levels/rates were not specified in the EMP, as such an arbitrary level/rate of ≤10% has been assigned.

5. Recommendations

5.1 Contingency measures

The EMP lists potential problems and contingency measures for various components of the monitoring program. Those that are considered to be relevant to the nest box monitoring program are listed and discussed in Table 6.

Table 6: Contingency measures

Potential Problem	Contingency Measure proposed in EMP	Discussion of proposed measure
Nest boxes being used by non-target species	Review the selection and number of nest box designs	<p>All nest box types showed use by non-target vertebrate fauna. As generalists, reptiles were expected, and observed, to use a range of nest box types.</p> <p>Almost all boxes showed use by possums which may exclude/compete with the targeted fauna. Additional monitoring events are required to determine a trend or an increase in use of other box types by possums. Future consideration of exclusion methods for Brushtail Possums, such as installing metal guards around trees, to prevent predation and resource competition may be necessary.</p> <p>At this stage, the level of use by non-target vertebrate fauna is not considered to warrant contingency measures as the nest boxes that are not being used by target fauna are also showing lower rates of use in general. Non-target fauna are therefore not considered to be excluding target fauna.</p> <p>The use of <10% of nest boxes by ants and wasps is not considered to warrant contingency measures. However should future monitoring observe ongoing use by these pest species and apparent singular use (i.e. no signs of dual occupancy), contingency measures may be required.</p> <p>This contingency measure is not considered relevant at this stage.</p>
Nest Boxes become occupied by exotic or invasive fauna (i.e. European Bees, Termites)	Review/modify nest box design to exclude undesirable species, treat if applicable (i.e. Buffalo Fly ear tags for bees) or relocate those boxes to another location	<p>Exotic birds were not recorded using the nest boxes in 2016/2017. Less than 10% of nest boxes (2.8% and 2.0% in summer and winter respectively), were either occupied or showed signs of occupation by European bees.</p> <p>This contingency measure is not considered relevant.</p>
Poor uptake/usage rate by native fauna	Review the types and number of nest box designs	<p>Seventeen native species have been identified during monitoring and 70% of nest boxes were occupied or showed signs of use by vertebrate fauna during the summer 2016 and winter 2017 monitoring periods.</p> <p>Microbats, owls and cockatoos have not been recorded using nest boxes during any monitoring event. Microbat roost box and nest box monitoring for the Oxley Highway to Kempsey Pacific Highway Upgrade has also found low uptake of target species in MB, COSO and LFO boxes (Niche 2017). While one monitoring event remains, based on the previous two monitoring events, it is considered unlikely that these fauna groups will be recorded using the nest boxes as currently installed. This is discussed further below.</p> <p>This contingency measure is considered relevant for MB, PL, COSO and LFO type nest boxes.</p>
Nest Boxes deteriorating rapidly and requiring maintenance	Identify causes of nest box failure, modify design and construct accordingly	<p>8.8% of boxes require maintenance/replacement at the end of the 2016/2017 monitoring period. Maintenance/replacement of these is being scheduled for autumn 2018.</p> <p>This contingency measure is not considered relevant.</p>

5.2 Recommendations

Monitoring to date has shown high rates of use of nest boxes by vertebrate fauna. Future monitoring events will provide information regarding the ongoing use of the nest boxes by non-target fauna and, to date, absent target fauna. Table 7 lists a number of recommendations to be taken into consideration due to the apparent low uptake rate of nest boxes by microbats, cockatoos, parrots and owls.

In addition to relevant contingency measures addressed in Table 7, maintenance should be undertaken as required to address all maintenance issues recorded during 2016/2017 inspections.

Table 7: Recommendations

Potential Problem	Contingency Measure proposed in EMP	Recommendation
Poor uptake/usage rate by native fauna	Review the types and number of nest box designs	<p>Recommendations relevant for MB roost boxes:</p> <p>According to the NBPoM (Lewis 2012), target species for microbat roost boxes were those species considered to roost in tree hollows, such as the Little Forest Bat (<i>Vespadelus vulturnus</i>), Chocolate Wattled Bat (<i>Chalinolobus morio</i>), Gould's Wattled Bat (<i>Chalinolobus gouldi</i>), Greater Broad-nosed Bat (<i>Scoteanax rueppellii</i>) and the White-striped Mastiff Bat (<i>Tadarida australis</i>). The NBPoM remarks that while a number of species were recorded from the area, there is no evidence of them using tree hollows within the clearing footprint. No microbats were recorded using roost boxes.</p> <p>A recent review of roost box use by microbats (Rueegger 2016) highlighted the lack of detailed knowledge regarding the factors determining uptake of roost boxes by microbats. Rueegger discussed variables including box design, entrance size and position, box microclimate and orientation, changing seasonal requirements, competitive interactions, natural cavity abundance and forest type and local bat abundance amongst others, as factors influencing the occupation of roost boxes by microbats. He also highlights the importance of deploying several different roost box designs and that a single box type is insufficient. Three of the species mentioned above (Chocolate Wattled Bat, Gould's Wattled Bat and Greater Broad-nosed Bat) have been previously documented using bat roost boxes, as such, detailed investigation of these species and others should be considered.</p> <p>It is recommended that:</p> <ul style="list-style-type: none"> • Discussions with the NSW EPA be undertaken to consider possible corrective actions, including discussion of the recommendations below. • A review of recent literature regarding target species and their roosting requirements and the use of roost boxes by microbats be undertaken to determine possible initial repositioning of roost boxes or, eventually, a change in roost box design and distribution.
		<p>Recommendations relevant for PL, COSO and LFO type nest boxes:</p> <p>According to the NBPoM, target species for these roost boxes were medium sized parrots/lorikeets, cockatoos (Black Cockatoos), small owls (Southern Boobook and Barn Owl), and large forest owls (Masked Owl, Sooty Owl, Powerful Owl). The NBPoM notes that there is limited evidence to suggest that cockatoos will use artificial nest boxes and anecdotal observations and literature, such as Goldingay and Stevens (2009), indicates that research regarding artificial hollow use by native bat and bird species is limited.</p> <p>It is recommended that:</p> <ul style="list-style-type: none"> • Discussions with the NSW EPA be undertaken to consider possible corrective actions, including discussion of the recommendations below. • A review of recent literature regarding the use of nest boxes by these fauna groups to determine their effectiveness as compensatory habitat and likelihood of uptake. • Depending on the outcome of the literature review, consider adapting performance indicators to reflect the likelihood of uptake by fauna known or not known to use nest boxes.

6. References

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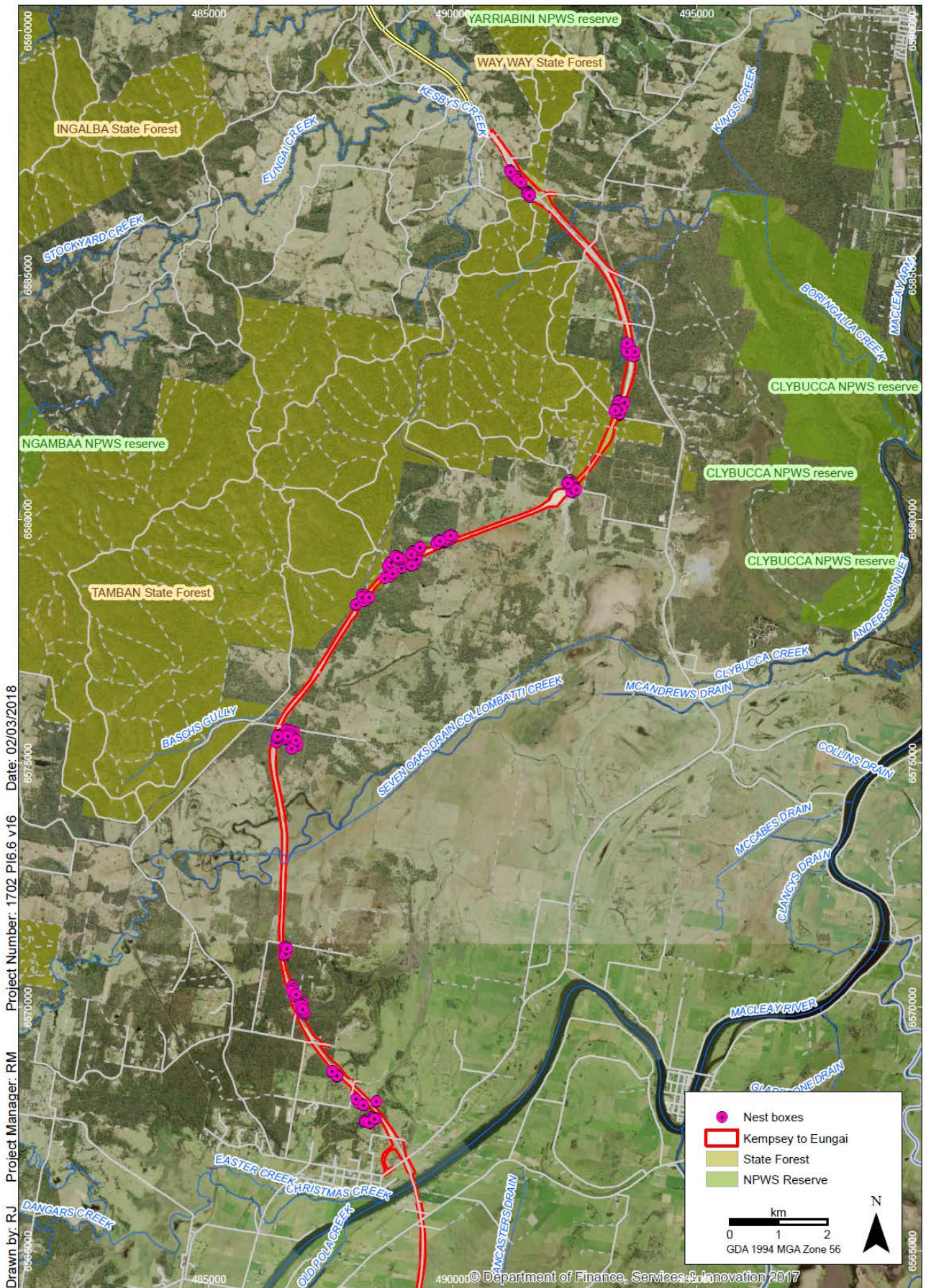
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Nest Box locations: Overview

Frederickton to Eungai – PI 6.6 Nest Box Monitoring

FIGURE 1

Annex 1 – Summer 2016 field data

Box N.	Nest Box Name	Zone	Type	Date	Time	Box height	Tree species	Inspect type	Occupied (Y/N)	Native/ Pest	Signs of use	Species	Changes in surrounding landscape	Comments
1	NBA.MB.01	A	Microbat	14.12.2016	8:50	4m	Broad-leaved Paper Bark	Cam	N		None		Nil	
2	NBA.MB.02	A	Microbat	14.12.2016	8:55	9m	Broad-leaved Paper Bark	Cam	N		None		Nil	
3	NBA.MB.03	A	Microbat	14.12.2016	8:40	5m	Broad-leaved Paper Bark	Cam	N		None		Nil	
4	NBA.MB.04	A	Microbat	14.12.2016	8:45	3m	Broad-leaved Paper Bark	Cam	N		Dense eucalypt leaves - possible antechinus or glider		Nil	
5	NBA.MB.05	A	Microbat	14.12.2016	9:05	4m	Broad-leaved Paper Bark	Cam	N		None		Nil	
6	NBA.MB.06	A	Microbat	14.12.2016	9:25	5m	Broad-leaved Paper Bark	Cam	N		None		Nil	
7	NBA.MB.07	A	Microbat	14.12.2016	9:25	5m	Broad-leaved Paper Bark	Cam	N		None		Nil	
8	NBA.MB.08	A	Microbat	14.12.2016	9:45	8m	Broad-leaved Paper Bark	Cam	N		None		Nil	
9	NBA.MB.09	A	Microbat	14.12.2016	9:55	6m	Broad-leaved Paper Bark	Cam	N		Bark packed into box - possible antechinus		Nil	
10	NBA.MB.10	A	Microbat	14.12.2016	9:35	13m	Broad-leaved Paper Bark	Cam	N		Insect nest		Nil	
11	NBA.MB.11	A	Microbat	14.12.2016	8:50	7m	Broad-leaved Paper Bark	Cam	N		None		Nil	
12	NBA.PL.01	A	Medium Sized Parrot	14.12.2016	9:15	13m	Broad-leaved Paper Bark	Cam	N		Chewed entrance, old birds nest (leaves, sticks, bark)		Nil	
13	NBA.PL.02	A	Medium Sized Parrot	14.12.2016	9:05	8m	Broad-leaved Paper Bark	Cam	N		Litter in bottom	Ringtail Possum drey	Nil	
14	NBA.PL.03	A	Medium Sized Parrot	14.12.2016	9:15	8m	Broad-leaved Paper Bark	Cam	N		Litter in bottom	Ringtail Possum drey	Nil	
15	NBA.PL.04	A	Medium Sized Parrot	14.12.2016	9:20	8m	Broad-leaved Paper Bark	Cam	Y	Native	occupied	Ringtail Possum	Nil	Exited box during inspection
16	NBA.PL.05	A	Medium Sized Parrot	14.12.2016	8:55	7m	Broad-leaved Paper Bark	Cam	N		Bark strips in bottom		Nil	
17	NBA.PL.06	A	Medium Sized Parrot	14.12.2016	9:45	12m	Broad-leaved Paper Bark	Cam	N		Old paperbark birds nest		Nil	
18	NBA.PL.07	A	Medium Sized Parrot	14.12.2016	9:50	10m	Swamp Oak	Cam	N		Old leaf nest		Nil	
19	NBA.PL.08	A	Medium Sized Parrot	14.12.2016	9:25	5m	Broad-leaved Paper Bark	Cam	N		Bark strips		Nil	
20	NBA.PL.09	A	Medium Sized Parrot	14.12.2016	9:37	9m	Swamp Oak	Cam	N		Bark and leaves		Nil	

Box N.	Nest Box Name	Zone	Type	Date	Time	Box height	Tree species	Inspect type	Occupied (Y/N)	Native/Pest	Signs of use	Species	Changes in surrounding landscape	Comments
21	NBA.PO.01	A	Possum	14.12.2016	9:00	6m	Broad-leaved Paper Bark	Cam	N		None		Nil	
22	NBA.PO.02	A	Possum	14.12.2016	9:05	12m	Broad-leaved Paper Bark	Cam	Y	Native	occupied	Common Brushtail Possum	Nil	
23	NBA.PO.03	A	Possum	14.12.2016	9:10	10m	Broad-leaved Paper Bark	Cam	Y	Native	occupied	Common Brushtail Possum	Nil	
24	NBA.PO.04	A	Possum	14.12.2016	8:40	8m	Broad-leaved Paper Bark	Cam	Y	Native	occupied	Pair of Crimson Rosellas	Nil	Flew out of box
25	NBB.MB.01	B	Microbat	20.12.2016	12:10	6m	Broad-leaved Paper Bark	Cam	N		None		Nil	
26	NBB.MB.02	B	Microbat	20.12.2016	12:12	6m	Broad-leaved Paper Bark	Cam	N		None		Nil	
27	NBB.PL.01	B	Medium Sized Parrot	13.12.2016	15:46	12m	Pink Bloodwood	Cam	Y	Native	Chewed entrance	Sugar Glider	Nil	Poking head out of box so did not open lid
28	NBB.PL.02	B	Medium Sized Parrot	13.12.2016	15:38	7m	Pink Bloodwood	Cam	N		Few old leaves		Nil	
29	NBB.PL.03	B	Medium Sized Parrot	13.12.2016	15:35	8m	Brush Box	Cam	N		Leaves - old glider nest		Nil	
30	NBB.PO.01	B	Possum	13.12.2016	16:00	12m	Pink Bloodwood	Cam	Y	Native	occupied	Common Brushtail Possum	Nil	
31	NBB.SF.01	B	Scansorial mammal	13.12.2016	15:45	9m	Brush Box	Cam	N		Couple of old leaves		Nil	
32	NBC.MB.01	C	Microbat	13.12.2016	16:48	12m	Pink Bloodwood	Cam	N		None		Nil	
33	NBC.MB.02	C	Microbat	13.12.2016	16:30	12m	Ironbark	Cam	N		None		Nil	
34	NBC.PL.01	C	Medium Sized Parrot	13.12.2016	17:00	8m	Grey Gum	Cam	N		Skull of small mammal		Nil	Possible use by Owl
35	NBC.PL.02	C	Medium Sized Parrot	13.12.2016	17:10	8m	Grey Gum	Cam	N		Woody debris; some scat, fur and/or feathers?		Nil	
36	NBC.PL.03	C	Medium Sized Parrot	13.12.2016	16:50	6m	Ironbark	Cam	N		Old birds nest - sticks and leaves		Nil	Possible use by Kookaburra?
37	NBC.PO.01	C	Possum	13.12.2016	16:35	8m	Pink Bloodwood	Cam	Y	Native	occupied	2 x Common Brushtail Possum	Nil	
39	NBC.SF.01	C	Scansorial mammal	13.12.2016	16:25	9m	Pink Bloodwood	Cam	N		Leaves - possible glider nest		Nil	
40	NBC.SF.02	C	Scansorial mammal	13.12.2016	16:45	9m	Ironbark	Cam	N		Leaves - possible glider		Nil	

Box N.	Nest Box Name	Zone	Type	Date	Time	Box height	Tree species	Inspect type	Occupied (Y/N)	Native/Pest	Signs of use	Species	Changes in surrounding landscape	Comments
											nest			
41	NBC.SF.03	C	Scansorial mammal	13.12.2016	16:35	8m	Pink Bloodwood	Cam	N		None		Nil	Spider web
42	NBC.SG.01	C	Small Glider	13.12.2016	17:00	5m	Grey Gum	Cam	N		Leaves - possible glider nest		Nil	
43	NBC.SG.02	C	Small Glider	13.12.2016	16:40	10m	Bloodwood	Cam	Y	Native	occupied	Sugar Glider	Nil	
44	NBD.CO.01	D	Cockatoo/Small Owl	1.3.2017	16:00	15m	Scribbly	Tree climber	Y	Native	occupied	Brushtail Possum	Nil	
45	NBD.LFO.01	D	Large Forest Owl	1.3.2017	17:00	19m	Scribbly	Tree Climber	N		Leaves		Nil	
46	NBD.LG.01	D	Large Glider	12.12.2016	12:50	6m	Stringy bark	Cam	N		Leaves possible glider nest		Nil	
47	NBD.LG.02	D	Large Glider	12.12.2016	13:10	13m	Stringy bark	Cam	Y	Native	occupied	Probable 3+ Sugar Glider	Nil	
48	NBD.LG.03	D	Large Glider	12.12.2016	16:50	8m	Scribbly	Cam	N		Dry leaves		Nil	
49	NBD.MB.01	D	Microbat	12.12.2016	12:10	6m	Tallowwood	Cam	N		None		Nil	
50	NBD.MB.02	D	Microbat	12.12.2016	12:20	6m	Stringy bark	Cam	N		None		Nil	2 sugar gliders in natural hollow near MB.02
51	NBD.PL.01	D	Medium Sized Parrot	12.12.2016	13:30	10m	Stringy bark	Cam	N		Leaves - possible glider nest		Nil	
52	NBD.PL.02	D	Medium Sized Parrot	12.12.2016	13:20	7m	Scribbly	Cam	N		None		Nil	
53	NBD.PO.01	D	Possum	12.12.2016	13:55	12m	Pink bloodwood	Cam	Y	Native	occupied	Common Brushtail Possum	Nil	
54	NBD.PO.02	D	Possum	12.12.2016	13:10	10m	Bloodwood	Cam	Y	Native	occupied	Common Brushtail Possum	Nil	
55	NBD.PO.03	D	Possum	12.12.2016	12:10	6m	Pink bloodwood	Cam	Y	Native	occupied	Common Brushtail Possum	Nil	Awake
56	NBD.SF.01	D	Scansorial mammal	12.12.2016	13:40	5m	Pink bloodwood	Cam	N		Leaves - possible glider nest		Nil	
57	NBD.SF.02	D	Scansorial mammal	12.12.2016	12:45	4m	Pink bloodwood	Cam	N		Leaves - possible old		Nil	

Box N.	Nest Box Name	Zone	Type	Date	Time	Box height	Tree species	Inspect type	Occupied (Y/N)	Native/Pest	Signs of use	Species	Changes in surrounding landscape	Comments
											glider nest			
58	NBD.SF.03	D	Scansorial mammal	12.12.2016	12:25	8m	Tallowwood	Cam	N		Leaves - possible old glider nest		Nil	
59	NBD.SF.04	D	Scansorial mammal	12.12.2016	12:30	6m	Pink bloodwood	Cam	Y	Native	occupied	Glider sp.	Nil	
60	NBD.SG.01	D	Small Glider	12.12.2016	15:40	7m	Pink bloodwood	Cam	N		Leaves - possible glider nest		Nil	
61	NBD.SG.02	D	Small Glider	12.12.2016	13:00	8m	Bloodwood	Cam	N		Leaves - possible glider nest		Nil	
62	NBD.SG.03	D	Small Glider	12.12.2016	13:15	9m	Stringy bark	Cam	N		Leaves - possible glider nest		Nil	
63	NBE.COSO.01	E	Cockatoo	13.12.2016	14:18	10m	Blackbutt	Cam	Y	Native	occupied	Common Brushtail Possum	Nil	
64	NBE.COSO.02	E	Cockatoo	13.12.2016	13:35	10m	Scribbly	Cam	Y	Native	occupied	Common Brushtail Possum	Nil	
65	NBE.LG.01	E	Large Glider	13.12.2016	14:10	7m	Blackbutt	Cam	N		Leaves/woodchips		Nil	
66	NBE.MB.01	E	Microbat	13.12.2016	14:00	10m	Scribbly gum	Cam	N		None		Nil	
68	NBE.MB.02	E	Microbat	13.12.2016	13:50	10m	Blackbutt	Cam	N		None		Nil	
67	NBE.MB.01	E		Duplicate									Nil	
69	NBE.PL.01	E	Medium Sized Parrot	13.12.2016	14:00	6m	Scribbly gum	Cam	N		Old leaf nest		Nil	
70	NBE.PL.02	E	Medium Sized Parrot	13.12.2016	13:35	8m	Blackbutt	Cam	Y		Ants	Ants	Nil	
71	NBE.PO.01	E	Possum	13.12.2016	13:40	7m	Blackbutt	Cam	N		Leaf drey		Nil	
72	NBE.PO.02	E	Possum	13.12.2016	14:35	8m	Blackbutt	Cam	N		Old leaf nest		Nil	
73	NBE.PO.03	E	Possum	13.12.2016	13:55	8m	Pink bloodwood	Cam	N		Leaf litter		Nil	
74	NBE.SF.01	E	Scansorial mammal	13.12.2016	14:45	7m	Blackbutt	Cam	N		Dry leaves - possible glider		Nil	
75	NBE.SF.02	E	Scansorial mammal	13.12.2016	13:50	6m	Blackbutt	Cam	N		Fresh eucalypt leaves in tight circle - probable glider nest		Nil	
76	NBE.SF.03	E	Scansorial mammal	13.12.2016	14:35	6m	Blackbutt	Cam	N		Fresh eucalypt leaves in tight circle - probable glider nest		Nil	

Box N.	Nest Box Name	Zone	Type	Date	Time	Box height	Tree species	Inspect type	Occupied (Y/N)	Native/Pest	Signs of use	Species	Changes in surrounding landscape	Comments
77	NBE.SG.01	E	Small Glider	13.12.2016	13:45	8m	Blackbutt	Cam	N		Bird feathers & leaves		Nil	
78	NBE.SG.02	E	Small Glider	13.12.2016	13:40	8m	White Mahogany	Cam	N		Green eucalypt leaves - possible glider nest		Nil	
79	NBE.SG.03	E	Small Glider	13.12.2016	13:50	7m	Blackbutt	Cam	N		Leaf nest	Couple of ants	Nil	
80	NBF.CO.04	F	Cockatoo/Small Owl	Not found			Scribbly gum						Nil	
81	NBF.LFO.01	F	Large Forest Owl	15.12.2016	11:30	10m	Bloodwood	Cam	N		Some leaf litter		Nil	Some whitewash around tree
82	NBF.LG.01	F	Large Glider	15.12.2016	11:15	8m	Pink bloodwood	Cam	Y	Native	Dead snake decomposing	Green Tree Snake?	Nil	
83	NBF.PL.01	F	Medium Sized Parrot	15.12.2016	13:38	9m	Stringy bark	Cam	N		Leaves		Nil	
84	NBF.PL.02	F	Medium Sized Parrot	15.12.2016	13:50	8m	Tallowwood	Cam	N		Dry leaves		Nil	
85	NBF.PO.01	F	Possum	15.12.2016	11:10	8m	Tallowwood	Cam	Y	Native	occupied	2 x Common Brushtail Possum	Nil	
86	NBF.PO.02	F	Possum	15.12.2016	13:42	10m	Stringy bark	Cam	N		Minor litter		Nil	
87	NBF.PO.03	F	Possum	15.12.2016	13:10	7m	Pink bloodwood	Cam	N		None		Nil	
88	NBF.PO.04	F	Possum	15.12.2016	12:20	7m	Pink bloodwood	Cam	Y	Native	occupied	Common Brushtail Possum	Nil	
89	NBF.PO.06	F	Possum	15.12.2016	9:44	12m	Pink bloodwood	Cam	Y	Native	occupied	Possibly 2 x Common Brushtail Possum	Nil	
90	NBF.PO.07	F	Possum	15.12.2016	10:12	5m	Black oak	Cam	N		None		Nil	
91	NBF.PO.08	F	Possum	15.12.2016	10:40	5m	Stringy bark	Cam	Y		Ants	Ants	Nil	
92	NBF.PO.09	F	Possum	15.12.2016	10:00	5m	Bloodwood	Cam	Y		Ants	Ants	Nil	
93	NBF.SF.01	F	Scansorial mammal	15.12.2016	13:22	6m	Stringy bark	Cam	N		Bark strips		Nil	
94	NBF.SF.02	F	Scansorial mammal	15.12.2016	14:00	5m	Pink bloodwood	Cam	Y	Native	occupied	4+ Sugar Gliders	Nil	
95	NBF.SF.03	F	Scansorial mammal	15.12.2016	13:04	12m	Pink bloodwood	Cam	N		Leaf drey - glider + pest		Nil	Mud wasp nest
96	NBF.SF.04	F	Scansorial mammal	15.12.2016	10:00	8m		Cam	N		None		Nil	
97	NBF.SF.05	F	Scansorial mammal	15.12.2016	10:15	8m	Black oak	Cam	N		Eucalypt leaf drey - glider		Nil	SG box?
98	NBF.SF.06	F	Scansorial mammal	15.12.2016	10:40	7m	Stringy bark	Cam	N		Eucalypt leaf drey - glider		Nil	
99	NBF.SG.01	F	Small Glider	15.12.2016	13:31	8m	Ironbark	Cam	Y	Native	occupied	4+ sugar gliders	Nil	

Box N.	Nest Box Name	Zone	Type	Date	Time	Box height	Tree species	Inspect type	Occupied (Y/N)	Native/Pest	Signs of use	Species	Changes in surrounding landscape	Comments
100	NBF.SG.02	F	Small Glider	15.12.2016	13:14	8m	Pink bloodwood	Cam	N		Eucalypt leaf drey - glider		Nil	
101	NBF.SG.03	F	Small Glider	15.12.2016	12:17	6m	Pink bloodwood	Cam	N		Eucalypt leaf drey - glider		Nil	
102	NBF.SG.04	F	Small Glider	15.12.2016	9:40	4m	Black oak	Cam	N		Some leaves		Nil	Crushed cones around tree GLBC
103	NBF.SG.05	F	Small Glider	15.12.2016	10:24	13m	Bloodwood	Cam	Y		Ants	Ants & eggs	Nil	Insect silk in opening
104	NBF.SG.06	F	Small Glider	15.12.2016	10:05	8m	Bloodwood	Cam	Y	Native	Glider and leaves	Sugar or Squirrel Glider	Nil	Nestled into leaves
105	NBF.SG.07	F	Small Glider	15.12.2016	9:52	14m	Bloodwood	Cam	N		Old leaves - possible old glider drey		Nil	
106	NBF.SO.01	F	Cockatoo/Small Owl	15.12.2016	13:26	8m	Tallowwood	Cam	N		Old leaves - possible old glider drey		Nil	
107	NBF.SO.02	F	Cockatoo/Small Owl	Not found									Nil	
108	NBG.PL.01	G	Medium Sized Parrot	14.12.2016	11:10	10m	Red mahogany	Cam	Y	Pest	Pest	Bees	Nil	Bee hive
109	NBG.PL.02	G	Medium Sized Parrot	14.12.2016	10:40	6m	Tallowwood	Cam	N		None		Nil	
110	NBG.PO.01	G	Possum	14.12.2016	10:45	10m	Red mahogany	Cam	N		Old leaf nest		Nil	
111	NBG.PO.02	G	Possum	14.12.2016	11:30	8m	Swamp mahogany	Cam	N		Old leaf nest		Nil	
112	NBG.SF.01	G	Scansorial mammal	14.12.2016	10:30	8m	Broad-leaved Paperbark	Cam	Y	Native	occupied	Sugar Glider	Nil	
113	NBG.SF.02	G	Scansorial mammal	14.12.2016	10:55	6m	Swamp Oak	Cam	N		Some leaf litter		Nil	
114	NBG.SF.03	G	Scansorial mammal	14.12.2016	11:20	7m	Swamp mahogany	Cam	Y	Native	occupied	Squirrel Glider	Nil	
115	NBG.SG.01	G	Small Glider	14.12.2016	10:35	4m	Swamp mahogany	Cam	N		None		Nil	
116	NBG.SG.02	G	Small Glider	14.12.2016	10:35	8m	Swamp mahogany	Cam	Y	Pest	Pest	Honeybee or wasp	Nil	
117	NBG.SG.03	G	Small Glider	14.12.2016	10:45	7m	Swamp oak	Cam	N		Melaleuca leaf drey		Nil	Old glider nest
118	NBH.LFO.01	H	Large Forest Owl	14.12.2016	13:15	15m	Blackbutt	Cam	Y	Native	occupied	Sugar Glider or Squirrel Glider	Nil	Fresh eucalypt leaf nest
119	NBH.LG.01	H	Large Glider	14.12.2016	11:55	7m	Blackbutt	Cam	N		Dry leaves - old glider nest		Nil	
120	NBH.PL.01	H	Medium Sized Parrot	20.12.2016	10:05	10m	Blackbutt	Cam	N		Fresh eucalypt leaf nest - possible glider		Nil	

Box N.	Nest Box Name	Zone	Type	Date	Time	Box height	Tree species	Inspect type	Occupied (Y/N)	Native/Pest	Signs of use	Species	Changes in surrounding landscape	Comments
121	NBH.PO.01	H	Possum	20.12.2016	10:21	7m	Tallowood	Cam	N		None		Nil	
122	NBH.PO.02	H	Possum	20.12.2016	10:28	6m	Pink bloodwood	Cam	N		None		Nil	
123	NBH.SF.01	H	Scansorial mammal	14.12.2016	12:05	8m	Blackbutt	Cam	N		Dry leaves - old glider nest		Nil	
124	NBH.SG.01	H	Scansorial mammal	20.12.2016	10:16	8m	Tallowood	Cam	N		Fresh eucalypt leaf nest - possible glider		Nil	
125	NBH.SO.01	H	Cockatoo/Small Owl	14.12.2016	13:05	12m	Blackbutt	Cam	N		Fresh eucalypt leaves		Nil	
126	NBI.CO.01	I	Cockatoo/Small Owl	20.12.2016	10:53	13m	Blackbutt	Cam	N		None		Nil	
127	NBI.LFO.01	I	Large Forest Owl	14.12.2016	12:50	13m	Blackbutt	Cam	N		Leaves and old stick nest		Nil	
128	NBI.LFO.02	I	Large Forest Owl	20.12.2016	11:02	15m	Blackbutt	Cam	N		Old leaves		Nil	
129	NBI.LG.01	I	Large Glider	14.12.2016	13:05	13m	Blackbutt	Cam	N		Old leaf nest		Nil	
130	NBI.LG.02	I	Large Glider	20.12.2016	11:44	11m	Blackbutt	Cam	N		Fresh leaf nest		Nil	
131	NBI.LG.03	I	Large Glider	20.12.2016	11:34	8m	Blackbutt	Cam	N		Fresh eucalypt leaf nest		Nil	
132	NBI.LG.04	I	Large Glider	14.12.2016	12:15	9m	Blackbutt	Cam	N		Fresh eucalypt leaves		Nil	
133	NBI.MB.01	I	Microbat	14.12.2016	12:15	10m	Blackbutt	Cam	N		White droppings		Nil	
134	NBI.PL.01	I	Medium Sized Parrot	20.12.2016	10:48	9m	Blackbutt	Cam	N		Old leaf nest		Nil	
135	NBI.PL.02	I	Medium Sized Parrot	20.12.2016	11:39	11m	Blackbutt	Cam	N		Old leaf nest		Nil	
136	NBI.PO.01	I	Possum	14.12.2016	12:25	3m	Blackbutt	Cam	N		Wood shavings		Nil	
137	NBI.PO.02	I	Possum	20.12.2016	10:59	8m	Blackbutt	Cam	N		Few leaves		Nil	
138	NBI.PO.03	I	Possum	14.12.2016	12:00	5m	Brushbox	Cam	N		None		Nil	
139	NBI.PO.04	I	Possum	14.12.2016	12:20	5m	Ironbark	Cam	N		None		Nil	
140	NBI.SF.01	I	Scansorial mammal	14.12.2016	12:30	7m	Tallowood	Cam	N		Dry leaves and bark around hole		Nil	
141	NBI.SF.02	I	Scansorial mammal	14.12.2016	12:30	8m	Tallowood	Cam	N		Fresh eucalypt leaves - probable glider nest		Nil	
142	NBI.SF.03	I	Scansorial mammal	14.12.2016	12:05	10m	Blackbutt	Cam	Y	Native	occupied	Sugar Glider or Squirrel Glider	Nil	
143	NBI.SG.01	I	Small Glider	14.12.2016	12:50	10m	Blackbutt	Cam	N		Old leaf nest		Nil	

Box N.	Nest Box Name	Zo ne	Type	Date	Time	Box height	Tree species	Inspe ct type	Occupied (Y/N)	Native/ Pest	Signs of use	Species	Changes in surrounding landscape	Comments
144	NBI.SG.02	I	Small Glider	20.12.2016	10:45	7m	Blackbutt	Cam	N		Fresh eucalypt leaf nest - probable glider		Nil	
145	NBI.SG.03	I	Small Glider	14.12.2016	12:10	10m	Blackbutt	Cam	N		None		Nil	
146	NBI.SO.02	I	Cockatoo/Small Owl	14.12.2016	12:25	15m	Blackbutt	Cam	Y	Native	occupied	Common Brushtail Possum	Nil	
147	NBJ.LG.01	J	Large Glider	15.12.2016	17:30	9m	Tallowwood	Cam	N		Dry leaves		Nil	2 wasps nests
148	NBJ.LG.02	J	Large Glider	15.12.2016	15:50	8m	Tallowwood	Cam	N		Dry leaves		Nil	
149	NBJ.LG.03	J	Large Glider	15.12.2016	17:40	7m	Ironbark	Cam	N		Broken up bark and leaves		Nil	
150	NBJ.LG.04	J	Large Glider	15.12.2016	16:47	7m	Ironbark	Cam	N		Broken up bark and leaves + Wasp/insect material		Nil	Wasp/insect material
151	NBJ.LG.05	J	Large Glider	15.12.2016	16:32	6m	Blackbutt	Cam	N		Bark and leaf fragments		Nil	Hanging forward at angle
152	NBJ.MB.01	J	Microbat	15.12.2016	15:55	8m	Pink bloodwood	Cam	N		None		Nil	
153	NBJ.MB.01	J		Duplicate									Nil	
154	NBJ.MB.02	J	Microbat	15.12.2016	16:30	5m	Pink bloodwood	Cam	N		None		Nil	
155	NBJ.MB.03	J	Microbat	15.12.2016	17:16	7m	Ironbark	Cam	N		None		Nil	
156	NBJ.PL.01	J	Medium Sized Parrot	15.12.2016	17:21	7m	Tallowwood	Cam	N		Bee honeycomb and leaves		Nil	
157	NBJ.PL.02	J	Medium Sized Parrot	15.12.2016	16:25	9m	Blackbutt	Cam	N		Dry leaves, box half full		Nil	
158	NBJ.PO.01	J	Possum	15.12.2016	16:10	4m	Tallowwood	Cam	Y		Ants		Nil	Ants and eggs
159	NBJ.PO.01	J		Duplicate									Nil	
160	NBJ.PO.02	J	Possum	15.12.2016	17:00	8m	Tallowwood	Cam	N		Leaf drey, box half full - likely glider		Nil	
161	NBJ.SF.01	J	Scansorial mammal	15.12.2016	17:23	8m	Tallowwood	Cam	N		Lots of bark		Nil	
162	NBJ.SF.02	J	Scansorial mammal	15.12.2016	17:03	5m	Pink bloodwood	Cam	N		Leaf drey, box half full - likely glider		Nil	
163	NBJ.SF.03	J	Scansorial mammal	15.12.2016	16:45	9m	Pink bloodwood	Cam	N		Dry leaves		Nil	
164	NBJ.SF.04	J	Scansorial mammal	15.12.2016	16:21	8m	Pink bloodwood	Cam	N		Dry leaves almost to		Nil	

Box N.	Nest Box Name	Zone	Type	Date	Time	Box height	Tree species	Inspect type	Occupied (Y/N)	Native/Pest	Signs of use	Species	Changes in surrounding landscape	Comments
											entrance level			
165	NBJ.SF.05	J	Scansorial mammal	15.12.2016	17:45	6m	Tallowwood	Cam	N		Dry leaves + mud wasp nest		Nil	Mud wasp nest
166	NBJ.SF.05	J		Duplicate									Nil	
167	NBJ.SG.01	J	Small Glider	15.12.2016	17:50	7m	Tallowwood	Cam	N		Dry leaves and bark strips		Nil	
168	NBJ.SG.02	J	Small Glider	15.12.2016	16:57	6m	Tallowwood	Cam	N		Glider drey	Glider sp.	Nil	
169	NBJ.SG.03	J	Small Glider	15.12.2016	16:20	6m	Blackbutt	Cam	N		3/4 full of dry leaves		Nil	
170	NBJ.SG.04	J	Small Glider	15.12.2016	17:10	10m	Ironbark	Cam	N		Leaves and possible bird scat		Nil	
171	NBJ.SG.05	J	Small Glider	15.12.2016	16:15	8m	Tallowwood	Cam	N		Dry leaves + loose honeycomb		Nil	Loose honeycomb
172	NBJ.SO.01	J	Cockatoo/Small Owl	15.12.2016	16:35	10m	Tallowwood	Cam	N		Dry leaves		Nil	
173	NBK.CO.02	K	Cockatoo/Small Owl	1.03.2017	18:00	15m	Tallowwood	Tree Climber	Y	Native	occupied	Brushtail Possum	Nil	
174	NBK.MB.01	K	Microbat	14.12.2016	16:12	10m	Blackbutt	Cam	N		None		Nil	
175	NBK.MB.02	K	Microbat	14.12.2016	16:45	10m	Blackbutt	Cam	N		None		Nil	
176	NBK.MB.03	K	Microbat	14.12.2016	16:25	7m	Blackbutt	Cam	N		None		Nil	
177	NBK.PL.01	K	Medium Sized Parrot	14.12.2016	17:00	5m	Stringy bark	Cam	N		None		Nil	
178	NBK.PL.02	K	Medium Sized Parrot	14.12.2016	16:10	6m	Blackbutt	Cam	N		Old brown eucalypt leaves		Nil	
179	NBK.PL.03	K	Medium Sized Parrot	14.12.2016	17:13	10m	Blackbutt	Cam	N		Old eucalypt leaves and honeycomb		Nil	
180	NBK.PO.01	K	Possum	14.12.2016	16:40	10m	Blackbutt	Visual observation	Y	Native	occupied	Dollarbird	Nil	Entered box, sat in entrance
181	NBK.PO.02	K	Possum	14.12.2016	16:40	8m	Blackbutt	Cam	Y	Native	occupied	Common Brushtail Possum	Nil	

Box N.	Nest Box Name	Zone	Type	Date	Time	Box height	Tree species	Inspect type	Occupied (Y/N)	Native/Pest	Signs of use	Species	Changes in surrounding landscape	Comments
182	NBK.SF.01	K	Scansorial mammal	14.12.2016	16:47	4m	Tallowwood	Cam	N		Lots of eucalyptus leaves		Nil	
183	NBK.SF.02	K	Scansorial mammal	14.12.2016	16:10	8m	Blackbutt	Cam	N		Leaf nest - fresh eucalypt		Nil	
184	NBK.SF.03	K	Scansorial mammal	14.12.2016	16:30	7m	Blackbutt	Cam	N		Old leaf nest		Nil	
185	NBK.SF.04	K	Scansorial mammal	14.12.2016	16:43	6m	Blackbutt	Cam	N		None		Nil	
186	NBK.SG.01	K	Small Glider	14.12.2016	16:45	5m	Blackbutt	Cam	N		Fresh eucalypt leaf nest - probable glider		Nil	
187	NBK.SG.02	K	Small Glider	14.12.2016	16:30	15m	Blackbutt	Cam	N		Old brown eucalypt leaves		Nil	
188	NBK.SG.04	K	Small Glider	14.12.2016	16:25	6m	White Mahogany	Cam	N		Old brown eucalypt leaves		Nil	Honeycomb on lid
189	NBK.SG.05	K	Small Glider	14.12.2016	16:16	6m	Pink bloodwood	Cam	Y		Fresh eucalypt leaf nest - probable glider + ants	Ants	Nil	
190	NBK.SG.06	K	Small Glider	14.12.2016	16:14	6m	Blackbutt	Cam	Y		Ants	Ants	Nil	
191	NBK.SO.01	K	Cockatoo/Small Owl	14.12.2016	17:05	15m	Tallowwood	Cam	Y	Native	occupied	Common Brushtail Possum	Nil	Eucalypt leaves
192	NBL.CO.01	L	Cockatoo/Small Owl	16.12.2016	8:40	9m	Grey Gum	Cam	Y	Native	occupied	Probable Common Brushtail Possum	Nil	
193	NBL.LG.01	L	Large Glider	16.12.2016	10:05	9m	Pink bloodwood	Cam	N		Brown leaves		Nil	
194	NBL.LG.02	L	Large Glider	16.12.2016	10:50	7m	Pink bloodwood	Cam	Y	Native	occupied	Lace Monitor	Nil	
195	NBL.LG.03	L	Large Glider	16.12.2016	9:45	8m	Bloodwood	Cam	N		Dry leaf nest		Nil	
196	NBL.LG.04	L	Large Glider	16.12.2016	9:40	8m	Ironbark	Cam	N		Brown leaves		Nil	
197	NBL.LG.05	L	Large Glider	16.12.2016	10:35	8m	Pink bloodwood	Cam	Y	Native	occupied	Lace Monitor	Nil	
198	NBL.MB.01	L	Microbat	14.12.2016	14:45	6m	Tallowwood	Cam	N		None		Nil	
199	NBL.MB.02	L	Microbat	14.12.2016	14:40	8m	Pink bloodwood	Cam	N		None		Nil	
201	NBL.MB.03	L	Microbat	14.12.2016	14:50	8m	Bloodwood	Cam	N		Pest	Insect nest	Nil	
202	NBL.MB.04	L	Microbat	14.12.2016	14:40	8m	Tallowwood	Cam	N		None		Nil	
203	NBL.PL.01	L	Medium Sized Parrot	14.12.2016	14:40	6m	Tallowwood	Cam	N		None		Nil	
204	NBL.PL.02	L	Medium Sized Parrot	Not found									Nil	
205	NBL.PL.03	L	Medium Sized Parrot	14.12.2016	15:10		White mahogany	Cam	N		Leaf litter		Nil	

Box N.	Nest Box Name	Zone	Type	Date	Time	Box height	Tree species	Inspect type	Occupied (Y/N)	Native/Pest	Signs of use	Species	Changes in surrounding landscape	Comments
206	NBL.PL.04	L	Medium Sized Parrot	14.12.2016	15:05	8m	Grey gum	Cam	N		Lots of old leaves		Nil	
207	NBL.PL.05	L	Medium Sized Parrot	14.12.2016	15:17	6m	Tallowwood	Cam	N		None		Nil	
208	NBL.PO.01	L	Possum	14.12.2016	15:00	7m	White mahogany	Cam	N		Dry leaves		Nil	
209	NBL.PO.02	L	Possum	14.12.2016	15:27	6m	Pink bloodwood	Cam	N		None		Nil	
210	NBL.PO.03	L	Possum	14.12.2016	15:10	8m	White mahogany	Cam	N		None		Nil	
211	NBL.PO.04	L	Possum	14.12.2016	15:15	6m	Pink bloodwood	Cam	Y		Ants	Ants	Nil	
212	NBL.PO.05	L	Possum	14.12.2016	15:15	5m	Blackbutt	Cam	N		Dry leaves - box half full - probable glider nest		Nil	
213	NBL.SF.01	L	Scansorial mammal	16.12.2016	10:25	5m	Tallowwood	Cam	Y		Ants	Full of ants	Nil	
214	NBL.SF.03	L	Scansorial mammal	16.12.2016	10:20	5m	Tallowwood	Cam	N		Dry leaves		Nil	
215	NBL.SF.04	L	Scansorial mammal	14.12.2016	14:55	7m	Pink bloodwood	Cam	N		Fresh leaves - probable glider		Nil	
216	NBL.SF.05	L	Scansorial mammal	14.12.2016	15:22	8m	Blackbutt	Cam	N		Fresh leaves - probable glider		Nil	
217	NBL.SG.01	L	Small Glider	16.12.2016	11:03	8m	Pink bloodwood	Cam	N		Dry leaves		Nil	1/3 full
218	NBL.SG.02	L	Small Glider	16.12.2016	10:30	6m	Pink bloodwood	Cam	N		Dry leaves and honeycomb		Nil	
219	NBL.SG.03	L	Small Glider	16.12.2016	10:15	10m	Pink bloodwood	Cam	N		Loose dry leaves		Nil	
220	NBL.SG.04	L	Small Glider	14.12.2016	15:20	8m	Tallowwood	Cam	N		Old leaves		Nil	
221	NBL.SG.05	L	Small Glider	14.12.2016	15:25	6m	Pink bloodwood	Cam	N		Empty		Nil	
222	NBL.SO.01	L	Cockatoo/Small Owl	16.12.2016	10:45	9m	Grey gum	Cam	Y	Native	occupied	2 x Common Brushtail Possum	Nil	
223	NBM.LG.01	M	Large Glider	13.12.2016	10:48	6m	Ironbark	Cam	N		Old eucalypt leaves and bark shavings		Nil	Possible old glider nest
224	NBM.LG.02	M	Large Glider	13.12.2016	11:00	5m	Ironbark	Cam	N		Old eucalypt leaves		Nil	
225	NBM.MB.01	M	Microbat	13.12.2016	10:40	6m	Ironbark	Cam	N		None		Nil	
226	NBM.MB.02	M	Microbat	13.12.2016	11:06	11m	White mahogany	Cam	N		None		Nil	
227	NBM.PL.01	M	Medium Sized Parrot	13.12.2016	10:55	7m	Ironbark	Cam	N		Old eucalypt leaves		Nil	Possible old glider nest

Box N.	Nest Box Name	Zone	Type	Date	Time	Box height	Tree species	Inspect type	Occupied (Y/N)	Native/ Pest	Signs of use	Species	Changes in surrounding landscape	Comments
228	NBM.PL.03	M	Medium Sized Parrot	13.12.2016	9:55	12m	Pink bloodwood	Cam	N		None		Nil	
229	NBM.PL.04	M	Medium Sized Parrot	13.12.2016	11:00	7m	Blackbutt	Cam	N		None		Nil	In same tree as SF08
230	NBM.PL.05	M	Medium Sized Parrot	13.12.2016	12:00	10m	Blackbutt	Cam	Y		Ants	Ants	Nil	
231	NBM.PL.06	M	Medium Sized Parrot	13.12.2016	10:55	5m	Blackbutt	Cam	N		None		Nil	
232	NBM.PO.01	M	Possum	13.12.2016	11:09	4m	White mahogany	Cam	N		Old leaf nest		Nil	
233	NBM.PO.03	M	Possum	13.12.2016	10:20	3m	Tallowwood	Cam	N		None		Nil	
234	NBM.PO.04	M	Possum	13.12.2016	10:00	5m	Bloodwood	Cam	Y	Native	occupied	Probable Common Brushtail Possum	Nil	
235	NBM.PO.05	M	Possum	13.12.2016	12:05	4m	Red mahogany	Cam	Y	Native	occupied	Brushtail Possum	Nil	
236	NBM.PO.06	M	Possum	13.12.2016	10:50	5m	Bloodwood	Cam	Y		Ants	Ants	Nil	
237	NBM.SF.01	M	Scansorial mammal	13.12.2016	10:30	8m	Tallowwood	Cam	N		Old leaf nest		Nil	Common Brushtail Possum sitting in trunk of tree behind nest box
238	NBM.SF.03	M	Scansorial mammal	13.12.2016			Tallowwood	Cam	Y		Ants	Possible ants nest	Nil	
239	NBM.SF.04	M	Scansorial mammal	13.12.2016	11:45	8m		Cam	Y		Ants	Ants	Nil	
240	NBM.SF.05	M	Scansorial mammal	13.12.2016	9:45	6m	Tallowwood	Cam	N		Fresh eucalypt leaf nest - probable glider nest		Nil	Wasp nest behind box.
241	NBM.SF.06	M	Scansorial mammal	13.12.2016	10:02	8m	Blackbutt	Cam	N		Fresh eucalypt leaf nest - probable glider nest		Nil	
242	NBM.SF.07	M	Scansorial mammal	13.12.2016	10:45	5m	Tallowwood	Cam	Y		Leaves - possible glider nest + ants	Ants & eggs	Nil	
243	NBM.SF.08	M	Scansorial mammal	13.12.2016	11:10	4m	Blackbutt	Cam	Y		Ants	Ants	Nil	
244	NBM.SG.01	M	Small Glider	13.12.2016	11:20	6m	Blackbutt	Cam	N		None		Nil	
245	NBM.SG.03	M	Small Glider	13.12.2016	9:58	6m	Pink bloodwood	Cam	N		Fresh eucalypt leaf nest - probable glider nest		Nil	
246	NBM.SG.04	M	Small Glider	13.12.2016	10:50		Bloodwood	Cam	Y		Ants	Ants	Nil	
247	NBM.SG.05	M	Small Glider	13.12.2016	11:15		Blackbutt	Cam	N		Leaves - probable glider		Nil	
248	NBM.SG.06	M	Small Glider	13.12.2016	10:00	6m	Tallowwood	Cam	N		Leaves - probable glider		Nil	

Box N.	Nest Box Name	Zone	Type	Date	Time	Box height	Tree species	Inspect type	Occupied (Y/N)	Native/ Pest	Signs of use	Species	Changes in surrounding landscape	Comments
249	NBM.SG.07	M	Small Glider	13.12.2016	10:30	6m	Tallowwood	Cam	N		Leaves - probable glider		Nil	
250	NBM.SG.08	M	Small Glider	13.12.2016	10:40	7m	Tallowwood	Cam	Y		Ants	Ants & eggs	Nil	
251	NBF.COSO.01	F	Cockatoo/Small Owl	Not in shapefile/missing			Tallowwood						Nil	
252	NBF.COSO.02	F	Cockatoo/Small Owl	15.12.2016	12:00	12m	Stringy bark	Cam	N		None		Nil	
253	NBF.COSO.03	F	Cockatoo/Small Owl	15.12.2016	11:40	12m	Tallowwood	Cam	N		Dry leaves		Nil	
254	NBF.COSO.04	F	Cockatoo/Small Owl	15.12.2016	11:10	9m	Ironbark	Cam	Y	Native	occupied	2 x Common Brushtail Possum	Nil	
255	NBF.PO.05	F	Possum	Not found									Nil	
256	NBK.SG.03	K	Small Glider	14.12.2016	16:15	9m	Blackbutt	Cam	N		Very full of leaves, some fresh		Nil	Wax cells inside lid (bees).
257	NBL.SF.02	L	Scansorial mammal	Not found									Nil	
258	NBM.PL.02	M	Medium Sized Parrot	13.12.2016	11:30	8m	Blackbutt	Cam	N		Leaves - probable glider		Nil	
259	NBM.PO.02	M	Possum	13.12.2016	11:21	7m	Tallowwood	Cam	Y	Native	occupied	Common Brushtail Possum	Nil	
260	NBM.SG.02	M	Small Glider	13.12.2016	10:15	5m	Tallowwood	Cam	N		Old eucalypt leaves - possible old glider nest		Nil	
261	NBM.SF.02	M	Scansorial mammal	13.12.2016	11:30	6m	Tallowwood	Cam	N		None		Nil	

Annex 2 – Winter 2017 field data

Box N.	Nest Box Name	Zone	Type	Date	Time	Box height	Tree species	Inspect Type	Occupied (Y/N)	Native / Pest	Signs of use	Species Name	Changes in surrounding landscape?	Comments
1	NBA.MB.01	A	Microbat	05/07/2017	15:13	4m	Broad-leaved Paper Bark	Cam	N		None		Nil	
2	NBA.MB.02	A	Microbat	05/07/2017	15:12	9m	Broad-leaved Paper Bark	Cam	N		None		Nil	
3	NBA.MB.03	A	Microbat	05/07/2017	15:15	5m	Broad-leaved Paper Bark	Cam	N		None		Nil	

Box N.	Nest Box Name	Zone	Type	Date	Time	Box height	Tree species	Inspect Type	Occupied (Y/N)	Native / Pest	Signs of use	Species Name	Changes in surrounding landscape?	Comments
4	NBA.MB.04	A	Microbat	05/07/2017	15:17	3m	Broad-leaved Paper Bark	Cam	N		None		Nil	
5	NBA.MB.05	A	Microbat	05/07/2017	15:19	4m	Broad-leaved Paper Bark	Cam	N		None		Nil	
6	NBA.MB.06	A	Microbat	05/07/2017	14:54	5m	Broad-leaved Paper Bark	Cam	N		None		Nil	
7	NBA.MB.07	A	Microbat	05/07/2017	14:56	5m	Broad-leaved Paper Bark	Cam	N		None		Nil	
8	NBA.MB.08	A	Microbat	05/07/2017	15:28	8m	Broad-leaved Paper Bark	Cam	N		None		Nil	
9	NBA.MB.09	A	Microbat	05/07/2017	15:31	6m	Broad-leaved Paper Bark	Cam	N		Leaf and Bark		Nil	
10	NBA.MB.10	A	Microbat	05/07/2017	15:37	13m	Broad-leaved Paper Bark	Cam	Y	Pest	Wasp Nest		Nil	
11	NBA.MB.11	A	Microbat	05/07/2017	16:10	7m	Broad-leaved Paper Bark	Cam	N		None		Nil	
12	NBA.PL.01	A	Medium Sized Parrot	05/07/2017	14:58	13m	Broad-leaved Paper Bark	Cam	N		Bark and leaf nest		Nil	Possible Ringtail Possum nest
13	NBA.PL.02	A	Medium Sized Parrot	05/07/2017	15:04	8m	Broad-leaved Paper Bark	Cam	N		Leaf nest		Nil	
14	NBA.PL.03	A	Medium Sized Parrot	05/07/2017	15:42	8m	Broad-leaved Paper Bark	Cam	N		Leaf nest		Nil	
15	NBA.PL.04	A	Medium Sized Parrot	05/07/2017	15:24	8m	Broad-leaved Paper Bark	Cam	N		Bark and leaf nest		Nil	Branch blocking access
16	NBA.PL.05	A	Medium Sized Parrot	05/07/2017	15:52	7m	Broad-leaved Paper Bark	Cam	N		Bark and leaf litter		Nil	
17	NBA.PL.06	A	Medium Sized Parrot	05/07/2017	16:00	12m	Broad-leaved Paper Bark	Cam	N		Bark and leaf		Nil	Scats in corner
18	NBA.PL.07	A	Medium Sized Parrot	05/07/2017	16:14	10m	Swamp Oak	Cam	N		Leaf litter		Nil	
19	NBA.PL.08	A	Medium Sized Parrot	05/07/2017	15:22	5m	Broad-leaved Paper Bark	Cam	N		Leaf litter		Nil	
20	NBA.PL.09	A	Medium Sized Parrot	05/07/2017	14:50	9m	Swamp Oak	Cam	Y	Native	occupied	Ringtail Possum	Nil	
21	NBA.PO.01	A	Possum	05/07/2017	15:11	6m	Broad-leaved Paper Bark	Cam	N		None		Nil	
22	NBA.PO.02	A	Possum	05/07/2017	15:05	12m	Broad-leaved Paper Bark	Cam	Y	Native	occupied	Common Brushtail Possum	Nil	
23	NBA.PO.03	A	Possum	05/07/2017	15:00	10m	Broad-leaved Paper Bark	Cam	Y	Native	occupied	Common Brushtail Possum	Nil	
24	NBA.PO.04	A	Possum	05/07/2017	15:58	8m	Broad-leaved Paper Bark	Cam	Y	Native	occupied	Common Brushtail Possum	Nil	
25	NBB.MB.01	B	Microbat	05/07/2017	10:50	6m	Broad-leaved Paper Bark	Cam	N		None		Nil	
26	NBB.MB.02	B	Microbat	05/07/2017	10:53	6m	Broad-leaved Paper Bark	Cam	Unknown		Unknown		Nil	Could not open. Needs

Box N.	Nest Box Name	Zo ne	Type	Date	Time	Box heig ht	Tree species	Inspe ct Type	Occupied (Y/N)	Native / Pest	Signs of use	Species Name	Changes in surrounding landscape?	Comments
														repositioning
27	NBB.PL.01	B	Medium Sized Parrot	05/07/2017	12:11	12m	Pink Bloodwood	Cam	Y	Native	occupied	Brush-tailed Phascogale	Nil	
28	NBB.PL.02	B	Medium Sized Parrot	05/07/2017	12:03	7m	Pink Bloodwood	Cam	N		Leaf litter		Nil	
29	NBB.PL.03	B	Medium Sized Parrot	05/07/2017	11:56	8m	Brushbox	Cam	N		Leaf litter		Nil	
30	NBB.PO.01	B	Possum	05/07/2017	12:16	12m	Pink Bloodwood	Cam	Y	Native	occupied	Common Brushtail Possum	Nil	
31	NBB.SF.01	B	Scansorial mammal	05/07/2017	12:24	9m	Brush Box	Cam	N		Leaf litter		Nil	
32	NBC.MB.01	C	Microbat	05/07/2017	12:56	12m	Pink Bloodwood	Cam	N		None		Nil	
33	NBC.MB.02	C	Microbat	05/07/2017	13:08	12m	Ironbark	Cam	N		None		Nil	
34	NBC.PL.01	C	Medium Sized Parrot	05/07/2017	13:33	8m	Grey Gum	Cam	N		Leaf litter		Nil	
35	NBC.PL.02	C	Medium Sized Parrot	05/07/2017	13:25	8m	Grey Gum	Cam	N		Leaf litter		Nil	
36	NBC.PL.03	C	Medium Sized Parrot	05/07/2017	13:02	6m	Ironbark	Cam	Y	Native	occupied	Green Tree Snake	Nil	
37	NBC.PO.01	C	Possum	05/07/2017	12:56	8m	Pink Bloodwood	Cam	Y	Native	occupied	Possum	Nil	
38	NBC.PO.02	C	Possum	05/07/2017	13:17			Cam	Y	Pest	Bees	Bees	Nil	
39	NBC.SF.01	C	Scansorial mammal	05/07/2017	12:54	9m	Pink Bloodwood	Cam	Y	Native	occupied	Yellow-bellied Glider	Nil	Multiple animals
40	NBC.SF.02	C	Scansorial mammal	05/07/2017	13:36	9m	Ironbark	Cam	N		Straw nest		Nil	
41	NBC.SF.03	C	Scansorial mammal	05/07/2017	12:50	8m	Pink Bloodwood	Cam	N		Leaf litter		Nil	
42	NBC.SG.01	C	Small Glider	05/07/2017	13:50	5m	Grey Gum	Cam	N		Conical leaf nest		Nil	
43	NBC.SG.02	C	Large Glider	05/07/2017	13:17			Cam	Y	Pest	Bees	Bees	Nil	is LG box type
44	NBD.CO.01	D	Cockatoo/Small Owl	05/07/2017	9:25	15m	Scribbly	Cam	N		None		Nil	
45	NBD.LFO.01	D	Large Forest Owl	31/08/2017	10:50	19m	Scribbly	Tree Climber	N		Leaf litter and hay material		Nil	
46	NBD.LG.01	D	Large Glider	05/07/2017	8:39	6m	Scribbly	Cam	N		Conical leaf nest		Nil	
47	NBD.LG.02	D	Large Glider	05/07/2017	8:27	13m	Stringy bark	Cam	N		Leaf nest		Nil	
48	NBD.LG.03	D	Large Glider	05/07/2017	9:53	8m	Scribbly	Cam	Y	Native	occupied	Yellow-bellied Glider	Nil	
49	NBD.MB.01	D	Microbat	05/07/2017	10:10	6m	Stringy bark	Cam	N		None		Nil	

Box N.	Nest Box Name	Zone	Type	Date	Time	Box height	Tree species	Inspect Type	Occupied (Y/N)	Native / Pest	Signs of use	Species Name	Changes in surrounding landscape?	Comments
50	NBD.MB.02	D	Microbat	05/07/2017	9:04	6m	Scribbly	Cam	N		None		Nil	
51	NBD.PL.01	D	Medium Sized Parrot	05/07/2017	9:18	10m	Scribbly	Cam	N		Leaf Nest		Nil	
52	NBD.PL.02	D	Medium Sized Parrot	05/07/2017	9:34	7m	Scribbly	Cam	Y	Native	occupied	Lace Monitor	Nil	
53	NBD.PO.01	D	Possum	05/07/2017	8:08	12m	Pink bloodwood	Cam	Y	Native	occupied	Common Brushtail Possum	Nil	
54	NBD.PO.02	D	Possum	05/07/2017	9:40	10m	Bloodwood	Cam	N		Messy Leaf litter		Nil	
55	NBD.PO.03	D	Possum	05/07/2017	8:56	6m	Stringy bark	Cam	Y	Native	occupied	Possum	Nil	
56	NBD.SF.01	D	Scansorial mammal	05/07/2017	8:14	5m	Pink bloodwood	Cam	Y	Native	occupied	Sugar Glider	Nil	Multiple animals
57	NBD.SF.02	D	Scansorial mammal	05/07/2017	8:44	4m	Pink bloodwood	Cam	Y	Native	occupied	Sugar Glider	Nil	
58	NBD.SF.03	D	Scansorial mammal	05/07/2017	10:06	8m	Stringy bark	Cam	N		Leaf nest		Nil	Direction of box wrong? (SE)
59	NBD.SF.04	D	Scansorial mammal	05/07/2017	10:02	6m	Pink bloodwood	Cam	N		Leaf nest		Nil	
60	NBD.SG.01	D	Small Glider	05/07/2017	8:21	7m	Pink bloodwood	Cam	Y	Native	occupied	Ringtail Possum	Nil	
61	NBD.SG.02	D	Small Glider	05/07/2017	9:47	8m	Bloodwood	Cam	N		Conical leaf nest and old wasp nests		Nil	
62	NBD.SG.03	D	Small Glider	05/07/2017	8:32	9m	Stringy bark	Cam	N		Leaf nest		Nil	
63	NBE.COSO.01	E	Cockatoo	05/07/2017	14:40	10m	Blackbutt	Cam	N		Bark		Nil	
64	NBE.COSO.02	E	Cockatoo	05/07/2017	14:59	10m	Scribbly	Cam	Y	Pest	Little leaf litter	Wasp	Nil	
65	NBE.LG.01	E	Large Glider	05/07/2017	14:16	7m	Blackbutt	Cam	N		Bark and leaf		Nil	
66	NBE.MB.01	E	Microbat	05/07/2017	14:41	10m	Scribbly gum	Cam	N				Nil	
67	NBE.MB.01	E		Duplicate									Nil	
68	NBE.MB.02	E	Microbat	05/07/2017	15:12	10m	Blackbutt	Cam	N		None		Nil	
69	NBE.PL.01	E	Medium Sized Parrot	05/07/2017	14:45	6m	Scribbly gum	Cam	Y	Native	occupied	Lace Monitor	Nil	
70	NBE.PL.02	E	Medium Sized Parrot	05/07/2017	14:11	8m	Stringy bark	Cam	N		None		Nil	no tag
71	NBE.PO.01	E	Possum	05/07/2017	13:57	7m	Blackbutt	Cam	N		Leaf litter		Nil	
72	NBE.PO.02	E	Possum	05/07/2017	14:22	8m	Blackbutt	Cam	N		Leaf and bark		Nil	no tag

Box N.	Nest Box Name	Zone	Type	Date	Time	Box height	Tree species	Inspect Type	Occupied (Y/N)	Native / Pest	Signs of use	Species Name	Changes in surrounding landscape?	Comments
73	NBE.PO.03	E	Possum	05/07/2017	14:06	8m	Pink bloodwood	Cam	N		Leaf litter		Nil	no tag
74	NBE.SF.01	E	Scansorial mammal	05/07/2017	14:14	7m	Blackbutt	Cam	N		Leaf nest		Nil	
75	NBE.SF.02	E	Scansorial mammal	05/07/2017	15:07	6m	Blackbutt	Cam	Y	Native	occupied	Common Brushtail Possum	Nil	
76	NBE.SF.03	E	Scansorial mammal	05/07/2017	14:22	6m	Blackbutt	Cam	N		Conical leaf nest		Nil	No tag
77	NBE.SG.01	E	Small Glider	05/07/2017	14:08	8m	Blackbutt	Cam	N		Leaf and Bark		Nil	
78	NBE.SG.02	E	Small Glider	05/07/2017	15:02	8m	White Mahogany	Cam	N		Conical leaf nest		Nil	
79	NBE.SG.03	E	Small Glider	05/07/2017	14:01	7m	Blackbutt	Cam	Y	Native	occupied	Common Brushtail Possum	Nil	
80	NBF.CO.04	F	Cockatoo/Small Owl	Not Found			Scribbly gum						Nil	
81	NBF.LFO.01	F	Large Forest Owl	05/07/2017	11:57	10m	Bloodwood	Cam	N		Leaf and Bark		Nil	Lost Tag
82	NBF.LG.01	F	Large Glider	05/07/2017	13:01	8m	Pink bloodwood	Cam	Y	Native	occupied	Common Brushtail Possum	Nil	
83	NBF.PL.01	F	Medium Sized Parrot	05/07/2017	14:02	9m	Stringy bark	Cam	N		Leaf and bark		Nil	
84	NBF.PL.02	F	Medium Sized Parrot	05/07/2017	14:33	8m	Tallowwood	Cam	Y	Native	occupied	Common Brushtail Possum	Nil	
85	NBF.PO.01	F	Possum	05/07/2017	14:50	8m	Tallowwood	Cam	N		Leaf litter		Nil	
86	NBF.PO.02	F	Possum	05/07/2017	13:52	10m	Stringy bark	Cam	Y	Native	occupied	Common Brushtail Possum	Nil	
87	NBF.PO.03	F	Possum	05/07/2017	13:17	7m	Pink bloodwood	Cam	N		Leaf nest		Nil	
88	NBF.PO.04	F	Possum	05/07/2017	13:11	7m	Pink bloodwood	Cam	N		None		Nil	
89	NBF.PO.06	F	Possum	05/07/2017	15:23	12m	Pink bloodwood	Cam	N		None		Nil	Visibility poor
90	NBF.PO.07	F	Possum	05/07/2017	16:01	5m	Black oak	Cam	N		None		Nil	
91	NBF.PO.08	F	Possum	05/07/2017	16:21	5m	Stringy bark	Cam	N		None		Nil	
92	NBF.PO.09	F	Possum	05/07/2017	15:51	5m	Bloodwood	Cam	N		None		Nil	
93	NBF.SF.01	F	Scansorial mammal	05/07/2017	14:11	6m	Stringy bark	Cam	N		Leaf and bark		Nil	
94	NBF.SF.02	F	Scansorial mammal	05/07/2017	14:41	5m	Pink bloodwood	Cam	N		Conical leaf nest		Nil	
95	NBF.SF.03	F	Scansorial mammal	05/07/2017	13:36	12m	Pink bloodwood	Cam	N		Leaf nest		Nil	

Box N.	Nest Box Name	Zone	Type	Date	Time	Box height	Tree species	Inspect Type	Occupied (Y/N)	Native / Pest	Signs of use	Species Name	Changes in surrounding landscape?	Comments
96	NBF.SF.04	F	Scansorial mammal	05/07/2017	16:10	8m		Cam	N		Leaf Litter		Nil	
97	NBF.SF.05	F	Scansorial mammal	05/07/2017	16:03	8m	Black oak	Cam	N		Leaf litter		Nil	
98	NBF.SF.06	F	Scansorial mammal	05/07/2017	16:23	7m	Stringy bark	Cam	N		Leaf and bark		Nil	no tag
99	NBF.SG.01	F	Small Glider	05/07/2017	14:06	8m	Ironbark	Cam	N		Leaf and bark		Nil	
100	NBF.SG.02	F	Small Glider	05/07/2017	13:25	8m	Pink bloodwood	Cam	Y	Pest	Leaf Nest	Bees	Nil	Bee Hive
101	NBF.SG.03	F	Small Glider	05/07/2017	13:08	6m	Pink bloodwood	Cam	N		Conical leaf nest		Nil	
102	NBF.SG.04	F	Small Glider	05/07/2017	15:20	4m	Black oak	Cam	N		Leaf litter		Nil	
103	NBF.SG.05	F	Small Glider	31/08/2017	7:45	13m	Bloodwood	Tree Climber	Y	Pest	None	Ants	Nil	Entrance completely blocked
104	NBF.SG.06	F	Small Glider	05/07/2017	15:51	8m	Bloodwood	Cam	N		Leaf litter		Nil	
105	NBF.SG.07	F	Small Glider	31/08/2017	8:15	14m	Bloodwood	Tree Climber	N		Leaf litter		Nil	Honeycomb on lid
106	NBF.SO.01	F	Cockatoo/Small Owl	05/07/2017	14:17	8m	Tallowwood	Cam	Y	Native	occupied	Common Brushtail Possum	Nil	
107	NBF.SO.02	F		Missing									Nil	
108	NBG.PL.01	G	Medium Sized Parrot	Not Found		10m	Red mahogany							
109	NBG.PL.02	G	Medium Sized Parrot	07/07/2017	8:30	6m	Tallowwood	Cam	N		Leaf litter nest		Nil	
110	NBG.PO.01	G	Possum	07/07/2017	8:32	10m	Red mahogany	Cam	N		Nest		Nil	Leaf litter, Bracken and Casuarina leaf.
111	NBG.PO.02	G	Possum	07/07/2017	9:25	8m	Swamp mahogany	Cam	Y	Native	occupied	Common Brushtail Possum	Nil	
112	NBG.SF.01	G	Scansorial mammal	07/07/2017	9:00	8m	Broad-leaved Paperbark	Cam	Y	Native	occupied	Gliders	Nil	Multiple animals
113	NBG.SF.02	G	Scansorial mammal	07/07/2017	9:43	6m	Swamp Oak	Cam	N		None		Nil	
114	NBG.SF.03	G	Scansorial mammal	07/07/2017	9:21	7m	Swamp mahogany	Cam	N		Leaf Nest		Nil	
115	NBG.SG.01	G	Small Glider	07/07/2017	8:23	4m	Swamp mahogany	Cam	Y	Native	occupied	Common Brushtail Possum	Nil	
116	NBG.SG.02	G	Small Glider	07/07/2017	9:13	8m	Swamp mahogany	Cam	N		Bark		Nil	

Box N.	Nest Box Name	Zone	Type	Date	Time	Box height	Tree species	Inspect Type	Occupied (Y/N)	Native / Pest	Signs of use	Species Name	Changes in surrounding landscape?	Comments
117	NBG.SG.03	G	Small Glider	07/07/2017	9:39	7m	Swamp oak	Cam	N		Leaf litter		Nil	
118	NBH.LFO.01	H	Large Forest Owl	07/07/2017	9:00	15m	Blackbutt	Cam	Y	Native	occupied	Sugar Gliders	Nil	Multiple animals
119	NBH.LG.01	H	Large Glider	07/07/2017	9:30	7m	Blackbutt	Cam	N		Conical leaf nest		Nil	
120	NBH.PL.01	H	Medium Sized Parrot	07/07/2017	9:30	10m	Blackbutt	Cam	N		Leaf nest		Nil	
121	NBH.PO.01	H	Possum	07/07/2017	9:46	7m	Tallowwood	Cam	N		Allocasuarina nest		Nil	
122	NBH.PO.02	H	Possum	07/07/2017	9:53	6m	Pink bloodwood	Cam	N		Messy Leaf litter		Nil	
123	NBH.SF.01	H	Scansorial mammal	07/07/2017	9:26	8m	Blackbutt	Cam	N		Glider nest		Nil	
124	NBH.SG.01	H	Scansorial mammal	07/07/2017	9:41	8m	Tallowwood	Cam	N		Conical leaf nest		Nil	
125	NBH.SO.01	H	Cockatoo/Small Owl	07/07/2017	9:18	12m	Blackbutt	Cam	N		None		Nil	
126	NBI.CO.01	I	Cockatoo/Small Owl	07/07/2017	9:12	13m	Blackbutt	Cam	N		Leaf litter		Nil	
127	NBI.LFO.01	I	Large Forest Owl	07/07/2017	10:08	13m	Blackbutt	Cam	N		Nest		Nil	
128	NBI.LFO.02	I	Large Forest Owl	31/08/2017	12:01	15m	Blackbutt	Tree Climber	N		Leaf litter and hay material		Nil	
129	NBI.LG.01	I	Large Glider	07/07/2017	10:18	13m	Blackbutt	Cam	N		Glider Nest		Nil	
130	NBI.LG.02	I	Large Glider	07/07/2017	8:32	11m	Blackbutt	Cam	N		Leaf Litter		Nil	
131	NBI.LG.03	I	Large Glider	07/07/2017	8:24	8m	Blackbutt	Cam	Y	Native	occupied	Yellow-bellied Glider	Nil	
132	NBI.LG.04	I	Large Glider	07/07/2017	9:09	9m	Blackbutt	Cam	N		Leaf nest		Nil	
133	NBI.MB.01	I	Microbat	07/07/2017	10:15	10m	Blackbutt	Cam	N		None		Nil	
134	NBI.PL.01	I	Medium Sized Parrot	07/07/2017	9:05	9m	Blackbutt	Cam	N		Leaf litter		Nil	
135	NBI.PL.02	I	Medium Sized Parrot	07/07/2017	8:35	11m	Blackbutt	Cam	N		Leaf litter		Nil	
136	NBI.PO.01	I	Possum	07/07/2017	9:50	3m	Blackbutt	Cam	N		None		Nil	
137	NBI.PO.02	I	Possum	Not found		8m	Blackbutt							
138	NBI.PO.03	I	Possum	07/07/2017	9:25	5m	Brushbox	Cam	N		None		Nil	
139	NBI.PO.04	I	Possum	07/07/2017	8:33	5m	Ironbark	Cam	N				Nil	
140	NBI.SF.01	I	Scansorial mammal	07/07/2017	10:00	7m	Tallowwood	Cam	N		Conical leaf nest		Nil	
141	NBI.SF.02	I	Scansorial mammal	07/07/2017	8:47	8m	Tallowwood	Cam	Y	Native	occupied	Sugar Glider	Nil	Multiple animals

Box N.	Nest Box Name	Zo ne	Type	Date	Time	Box heig ht	Tree species	Inspe ct Type	Occupied (Y/N)	Native / Pest	Signs of use	Species Name	Changes in surrounding landscape?	Comments
142	NBI.SF.03	I	Scansorial mammal	07/07/2017	9:22	10m	Blackbutt	Cam	N		Conical leaf nest		Nil	
143	NBI.SG.01	I	Small Glider	07/07/2017	10:24	10m	Blackbutt	Cam	Y	Native	occupied	Lace Monitor	Nil	
144	NBI.SG.02	I	Small Glider	07/07/2017	9:01	7m	Blackbutt	Cam	N		Leaf Litter		Nil	
145	NBI.SG.03	I	Small Glider	07/07/2017	9:33	10m	Blackbutt	Cam	N		Conical leaf nest		Nil	
146	NBI.SO.02	I	Cockatoo/Small Owl	31/08/2017	9:30	15m	Blackbutt	Tree Climber	N		Leaf litter		Nil	
147	NBJ.LG.01	J	Large Glider	07/07/2017	12:15	9m	Tallowwood	Cam	Y	Native	occupied	Common Brushtail Possum	Nil	
148	NBJ.LG.02	J	Large Glider	07/07/2017	11:10	8m	Tallowwood	Cam	N		Leaf litter		Nil	
149	NBJ.LG.03	J	Large Glider	07/07/2017	12:00	7m	Ironbark	Cam	N		Chewed Litter		Nil	
150	NBJ.LG.04	J	Large Glider	07/07/2017	11:55	7m	Ironbark	Cam	N		Neat nest with bark		Nil	
151	NBJ.LG.05	J	Large Glider	07/07/2017	10:50	6m	Blackbutt	Cam	N		Messy Leaf litter		Nil	
152	NBJ.MB.01	J	Microbat	07/07/2017	11:20	8m	Pink bloodwood	Cam	N		None		Nil	
153	NBJ.MB.01	J		Duplicate									Nil	
154	NBJ.MB.02	J	Microbat	07/07/2017	10:40	5m	Pink bloodwood	Cam	N		None		Nil	
155	NBJ.MB.03	J	Microbat	07/07/2017	12:30	7m	Ironbark	Cam	N		None		Nil	
156	NBJ.PL.01	J	Medium Sized Parrot	07/07/2017	12:30	7m	Tallowwood	Cam	N		Bark		Nil	
157	NBJ.PL.02	J	Medium Sized Parrot	07/07/2017	10:40	9m	Blackbutt	Cam	N		Conical leaf nest		Nil	
158	NBJ.PO.01	J	Possum	07/07/2017	10:20	4m	Tallowwood	Cam	N		None		Nil	
159	NBJ.PO.01	J		Duplicate									Nil	
160	NBJ.PO.02	J	Possum	07/07/2017	11:40	8m	Tallowwood	Cam	N		Full of leaf		Nil	
161	NBJ.SF.01	J	Scansorial mammal	07/07/2017	12:30	8m	Tallowwood	Cam	N		Leaf and Bark		Nil	
162	NBJ.SF.02	J	Scansorial mammal	07/07/2017	11:45	5m	Pink bloodwood	Cam	N		Leaf litter		Nil	
163	NBJ.SF.03	J	Scansorial mammal	07/07/2017	12:30	9m	Pink bloodwood	Cam	N		Leaf litter		Nil	
164	NBJ.SF.04	J	Scansorial mammal	07/07/2017	11:00	8m	Pink bloodwood	Cam	N		Leaf litter		Nil	
165	NBJ.SF.05	J	Scansorial mammal	07/07/2017	12:00	6m	Tallowwood	Cam	N		Leaf litter		Nil	
166	NBJ.SF.05	J		Duplicate									Nil	

Box N.	Nest Box Name	Zo ne	Type	Date	Time	Box heig ht	Tree species	Inspe ct Type	Occupied (Y/N)	Native / Pest	Signs of use	Species Name	Changes in surrounding landscape?	Comments
167	NBJ.SG.01	J	Small Glider	07/07/2017	12:00	7m	Tallowwood	Cam	N		Leaf litter		Nil	
168	NBJ.SG.02	J	Small Glider	07/07/2017	11:50	6m	Tallowwood	Cam	N		Conical leaf nest		Nil	
169	NBJ.SG.03	J	Small Glider	07/07/2017	10:30	6m	Blackbutt	Cam	N		Conical leaf nest		Nil	
170	NBJ.SG.04	J	Small Glider	07/07/2017	11:30	10m	Ironbark	Cam	N		Allocasuarina nest		Nil	
171	NBJ.SG.05	J	Small Glider	07/07/2017	10:10	8m	Tallowwood	Cam	N		Leaf litter		Nil	
172	NBJ.SO.01	J	Cockatoo/Small Owl	07/07/2017	12:15	10m	Tallowwood	Cam	N		Messy leaf litter		Nil	
173	NBK.CO.02	K	Cockatoo/Small Owl	06/07/2017	14:05	15m	Tallowwood	Cam	N		None		Nil	
174	NBK.MB.01	K	Microbat	06/07/2017	14:43	10m	Blackbutt	Cam	N		None		Nil	
175	NBK.MB.02	K	Microbat	06/07/2017	13:28	10m	Blackbutt	Cam	N		None		Nil	
176	NBK.MB.03	K	Microbat	06/07/2017	13:41	7m	Blackbutt	Cam	N		None		Nil	
177	NBK.PL.01	K	Medium Sized Parrot	06/07/2017	14:57	5m	Stringy bark	Cam	N		Stringybark nest		Nil	Scats
178	NBK.PL.02	K	Medium Sized Parrot	06/07/2017	14:48	6m	Blackbutt	Cam	N		Bark and leaf nest		Nil	
179	NBK.PL.03	K	Medium Sized Parrot	06/07/2017	13:40	10m	Blackbutt	Cam	N		Leaf litter		Nil	
180	NBK.PO.01	K	Possum	06/07/2017	13:31	10m	Blackbutt	Visual observation	N		Leaf litter		Nil	
181	NBK.PO.02	K	Possum	06/07/2017	14:17	8m	Blackbutt	Cam	Y	Native	occupied	Common Brushtail Possum	Nil	
182	NBK.SF.01	K	Scansorial mammal	06/07/2017	14:09	4m	Tallowwood	Cam	N		Leaf nest		Nil	
183	NBK.SF.02E	K	Scansorial mammal	06/07/2017	13:52	8m	Blackbutt	Cam	N		Melaleuca bark		Nil	
184	NBK.SF.03	K	Scansorial mammal	06/07/2017	13:35	7m	Blackbutt	Cam	N		Leaf nest		Nil	
185	NBK.SF.04	K	Scansorial mammal	06/07/2017	14:13	6m	Tallowwood	Cam	N		leaf and bark nest		Nil	
186	NBK.SG.01	K	Small Glider	06/07/2017	14:12	5m	Blackbutt	Cam	N		Conical leaf nest		Nil	
187	NBK.SF.02 W	K	Small Glider	06/07/2017	14:20		Blackbutt	Cam	Y	Native	occupied	Sugar Gliders	Nil	x2
187	NBK.SG.02	K	Small Glider	Not Found		15m	Blackbutt							
188	NBK.SG.04	K	Small Glider	06/07/2017	14:30	6m	White Mahogany	Cam	N		Conical leaf nest		Nil	

Box N.	Nest Box Name	Zone	Type	Date	Time	Box height	Tree species	Inspect Type	Occupied (Y/N)	Native / Pest	Signs of use	Species Name	Changes in surrounding landscape?	Comments
189	NBK.SG.05	K	Small Glider	06/07/2017	14:39	6m	Pink bloodwood	Cam	N		Leaf nest		Nil	
190	NBK.SG.06	K	Small Glider	06/07/2017	14:36	6m	Blackbutt	Cam	N		None		Nil	
191	NBK.SO.01	K	Cockatoo/Small Owl	06/07/2017	13:25	15m	Blackbutt	Cam	N		Leaf nest		Nil	
192	NBL.CO.01	L	Cockatoo/Small Owl	06/07/2017	12:36	9m	Grey Gum	Cam	N		None		Fire	
193	NBL.LG.01	L	Large Glider	Not Found		9m	Pink bloodwood							
194	NBL.LG.02	L	Large Glider	06/07/2017	9:47	7m	Pink bloodwood	Cam	Y	Pest	Wasp nest	Wasp	Lantana	
195	NBL.LG.03	L	Large Glider	06/07/2017	12:54	8m	Bloodwood	Cam	N		Leaf litter		Fire	
196	NBL.LG.04	L	Large Glider	06/07/2017	12:49	8m	Ironbark	Cam	N		Conical leaf nest		Fire	
197	NBL.LG.05	L	Large Glider	06/07/2017	9:42	8m	Pink bloodwood	Cam	N		Leaf nest		Lantana	
198	NBL.MB.01	L	Microbat	06/07/2017	15:35	6m	Tallowwood	Cam	N		None		Nil	
199	NBL.MB.02	L	Microbat	06/07/2017	15:26	8m	Pink bloodwood	Cam	N		None		Nil	
200	NBL.MB.02	L	Microbat	Duplicate										
201	NBL.MB.03	L	Microbat	06/07/2017	15:40	8m	Bloodwood	Cam	N		None		Nil	
202	NBL.MB.04	L	Microbat	06/07/2017	15:30	8m	Tallowwood	Cam	N		None		Nil	
203	NBL.PL.01	L	Medium Sized Parrot	06/07/2017	15:30	6m	Tallowwood	Cam	N		Leaf litter		Nil	
204	NBL.PL.02	L	Medium Sized Parrot	Not found										
205	NBL.PL.03	L	Medium Sized Parrot	06/07/2017	15:55		White mahogany	Cam	N		Leaf litter		Nil	
206	NBL.PL.04	L	Medium Sized Parrot	06/07/2017	8:48	8m	Grey gum	Cam	N		Conical leaf nest		Nil	
207	NBL.PL.05	L	Medium Sized Parrot	06/07/2017	8:35	6m	Tallowwood	Cam	N		None		Nil	
208	NBL.PO.01	L	Possum	06/07/2017	8:20	7m	White mahogany	Cam	N		Chewed leaf and bark		Nil	
209	NBL.PO.02	L	Possum	06/07/2017	15:48	6m	Pink bloodwood	Cam	N		Leaf litter		Nil	
210	NBL.PO.03	L	Possum	06/07/2017	8:52	8m	White mahogany	Cam	N		None		Nil	
211	NBL.PO.04	L	Possum	06/07/2017	8:42	6m	Pink bloodwood	Cam	Y	Pest	Bees/Wasps	Bees	Nil	Infested
212	NBL.PO.05	L	Possum	06/07/2017	15:56	5m	Blackbutt	Cam	N		Leaf litter		Nil	
213	NBL.SF.01	L	Scansorial mammal	06/07/2017	9:24	5m	Tallowwood	Cam	Y	Ants	Infested	Ants	Lantana	
214	NBL.SF.03	L	Scansorial mammal	06/07/2017	9:28	5m	Tallowwood	Cam	N		Conical leaf nest		Lantana	
215	NBL.SF.04	L	Scansorial mammal	06/07/2017	15:43	7m	Pink bloodwood	Cam	N		Leaf litter		Nil	

Box N.	Nest Box Name	Zone	Type	Date	Time	Box height	Tree species	Inspect Type	Occupied (Y/N)	Native / Pest	Signs of use	Species Name	Changes in surrounding landscape?	Comments
216	NBL.SF.05	L	Scansorial mammal	06/07/2017	8:28	8m	Blackbutt	Cam	N		Leaf litter		Nil	
217	NBL.SG.01	L	Small Glider	06/07/2017	12:58	8m	Pink bloodwood	Cam	N		Leaf nest		Fire	
218	NBL.SG.02	L	Small Glider	06/07/2017	9:33	6m	Pink bloodwood	Cam	N		Leaf litter		Lantana	
219	NBL.SG.03	L	Small Glider	06/07/2017	10:05	10m	Pink bloodwood	Cam	N		Leaf litter		Lantana	
220	NBL.SG.04	L	Small Glider	06/07/2017	8:31	8m	Tallowwood	Cam	N		Full of leaf		Nil	
221	NBL.SG.05	L	Small Glider	06/07/2017	8:25	6m	Pink bloodwood	Cam	N		Leaf litter		Nil	
222	NBL.SO.01	L	Cockatoo/Small Owl	06/07/2017	9:50	9m	Grey gum	Cam	Y	Native	occupied	Ringtail Possum	Lantana	x2
223	NBM.LG.01	M	Large Glider	06/07/2017	11:05	6m	Ironbark	Cam	N		Leaf litter		Nil	
224	NBM.LG.02	M	Large Glider	06/07/2017	10:59	5m	Ironbark	Cam	N		Leaf litter		Nil	
225	NBM.MB.01	M	Microbat	06/07/2017	11:14	6m	Ironbark	Cam	N		None		Nil	
226	NBM.MB.02	M	Microbat	06/07/2017	10:57	11m	White mahogany	Cam	N		None		Nil	
227	NBM.PL.01	M	Medium Sized Parrot	30/06/2017	11:03	7m	Ironbark	Cam	N		Leaf litter		Nil	
228	NBM.PL.03	M	Medium Sized Parrot	30/06/2017	11:17	12m	Pink bloodwood	Cam	N		None		Nil	
229	NBM.PL.04	M	Medium Sized Parrot	30/06/2017	12:10	7m	Blackbutt	Cam	N		None		Nil	
230	NBM.PL.05	M	Medium Sized Parrot	30/06/2017	12:17	10m	Blackbutt	Cam	Y	Ants	Ants	Ants	Nil	
231	NBM.PL.06	M	Medium Sized Parrot	30/06/2017	11:58	5m	Blackbutt	Cam	N		None		Nil	
232	NBM.PO.01	M	Possum	06/07/2017	10:55	4m	White mahogany	Cam	Y	Native	occupied	Common Brushtail Possum	Nil	
233	NBM.PO.03	M	Possum	30/06/2017	11:21	3m	Tallowwood	Cam	Y	Ants	Ants	Ants	Nil	
234	NBM.PO.04	M	Possum	30/06/2017	11:02	5m	Tallowwood	Cam	N		None		Nil	
235	NBM.PO.05	M	Possum	30/06/2017	11:15	4m	Red mahogany	Cam	N		None		Nil	
236	NBM.PO.06	M	Possum	30/06/2017	11:51	5m	Bloodwood	Cam	N		None		Nil	
237	NBM.SF.01	M	Scansorial mammal	06/07/2017	11:09	8m	Tallowwood	Cam	N		Conical leaf nest		Nil	
238	NBM.SF.03	M	Scansorial mammal	30/06/2017	11:22		Tallowwood	Cam	N		None		Nil	
239	NBM.SF.04	M	Scansorial mammal	30/06/2017	11:55	8m		Cam	N		Leaf nest		Nil	
240	NBM.SF.05	M	Scansorial mammal	30/06/2017	10:53	6m	Tallowwood	Cam	N		Leaf nest		Nil	

Box N.	Nest Box Name	Zone	Type	Date	Time	Box height	Tree species	Inspect Type	Occupied (Y/N)	Native / Pest	Signs of use	Species Name	Changes in surrounding landscape?	Comments
241	NBM.SF.06	M	Scansorial mammal	30/06/2017	11:02	8m	Blackbutt	Cam	N		Leaf nest		Nil	
242	NBM.SF.07	M	Scansorial mammal	30/06/2017	12:19	5m	Tallowwood	Cam	N		Leaf nest		Nil	
243	NBM.SF.08	M	Scansorial mammal	30/06/2017	12:08	4m	Blackbutt	Cam	Y	Ants	Ants	Ants	Nil	
244	NBM.SG.01	M	Small Glider	06/07/2017	11:24	6m	Blackbutt	Cam	N		None		Nil	
245	NBM.SG.03	M	Small Glider	30/06/2017	11:18	6m	Pink bloodwood	Cam	N		Leaf nest		Nil	
246	NBM.SG.04	M	Small Glider	30/06/2017	11:53		Bloodwood	Cam	N		None		Nil	
247	NBM.SG.05	M	Small Glider	30/06/2017	12:13		Blackbutt	Cam	N		Leaf nest		Nil	
248	NBM.SG.06	M	Small Glider	30/06/2017	11:13	6m	Tallowwood	Cam	N		Leaf nest		Nil	
249	NBM.SG.07	M	Small Glider	30/06/2017	10:47	6m	Tallowwood	Cam	N		Leaf litter		Nil	
250	NBM.SG.08	M	Small Glider	30/06/2017	11:37	7m	Tallowwood	Cam	Y	Ants	Ants	Ants	Nil	
251	NBF.COSO.01	F	Cockatoo/Small Owl	Not in shapefile/missing			Tallowwood							
252	NBF.COSO.02	F	Cockatoo/Small Owl	05/07/2017	Not found/not in shapefile									
253	NBF.COSO.03	F	Cockatoo/Small Owl	05/07/2017	11:12	12m	Tallowwood	Cam	Y	Native	occupied	Common Brushtail Possum	Nil	
254	NBF.COSO.04	F	Cockatoo/Small Owl	31/08/2017	8:36	9m	Ironbark	Tree Climber	N		None		Nil	Completely empty/bare
255	NBF.PO.05	F	Possum	Not found										No GPS point
256	NBK.SG.03	K	Small Glider	06/07/2017	13:44	9m	Blackbutt	Cam	Y	Native	occupied	Likely Sugar Glider	Nil	
257	NBL.SF.02	L	Scansorial mammal	Not found										
258	NBM.PL.02	M	Medium Sized Parrot	06/07/2017	10:41	8m	Blackbutt	Cam	Y	Native	occupied	Lace Monitor	Nil	
259	NBM.PO.02	M	Possum	30/06/2017	12:01	7m	Tallowwood	Cam	N		Leaf litter		Nil	
260	NBM.SG.02	M	Small Glider	06/07/2017	11:31	5m	Tallowwood	Cam	N		Leaf litter		Nil	
261	NBM.SF.02	M	Scansorial mammal	06/07/2017	11:34	6m	Tallowwood	Cam	N		Leaf litter		Nil	

Annex 3 – Survey Weather

Season	Date	Wind	Rain (mm)	Cloud Cover	Temperature (°C)
Summer	12.12.2016	0	0	0	27
Summer	13.12.2016	2	0	1	30
Summer	14.12.2016	0	0	1	25
Summer	15.12.2016	1	0	2	30
Summer	16.12.2016	0	2	7	24
Summer	20.12.2016	0	0	2	26
Summer	01.03.2017	0	0	0	27
Winter	30.06.2017	0	0	10	16
Winter	05.07.2017	0	0	0	11
Winter	06.07.2017	0	0	0	15
Winter	07.07.2017	0	0	60	12.5
Winter	31.08.2017	1	0	0	11

Note: wind and rain were recorded on a scale of 0-3, 0= no wind or rain.

Annex 4 - Data analysis for each zone

Zone	No. inspected		% Occupied with native species (n)		% Signs of use (n)		% Pests/signs of pest use (n)		No. requiring maintenance	
	Summer	Winter	Summer	Winter	Summer	Winter	Summer	Winter	Summer	Winter
A	24	24	16.7 (4)	16.7 (4)	41.7 (10)	37.5 (9)	4.2 (1)	4.2 (1)	1	3
B	7	7	28.6 (2)	28.6 (2)	42.9 (3)	42.9 (3)	0	0	0	1
C	11	12	18.2 (2)	25 (3)	54.5 (6)	41.7 (5)	0	16.7 (2)	0	2
D	20	19	30 (6)	36.8 (7)	55 (11)	42.1 (8)	0	5.3 (1)	0	1
E	16	16	12.5 (2)	18.8 (3)	68.8 (11)	62.5 (10)	6.3 (1)	6.3 (1)	1	1
F	29	28	27.6 (8)	17.9 (5)	48.3 (14)	57.1 (16)	13.8 (4)	10.7 (3)	6	5
G	10	10	20 (2)	30 (3)	40 (4)	50 (5)	20 (2)	0	2	0
H	8	8	12.5 (1)	12.5 (1)	62.5 (5)	75 (6)	0	0	0	0
I	21	21	9.5 (2)	14.3 (3)	76.2 (16)	61.9 (13)	0	0	0	0
J	23	23	0	4.3 (1)	78.3 (18)	78.3 (18)	21.7 (5)	0	6	0
K	20	20	20 (4)	15 (3)	50 (10)	60 (12)	15 (3)	0	4	0
L	29	29	13.8 (4)	3.4 (1)	48.3 (14)	58.6 (17)	13.8 (4)	10.3 (3)	5	5
M	32	32	9.4 (3)	6.3 (2)	43.8 (14)	46.9 (15)	25 (8)	12.5 (4)	9	4
Total	250	249	16.1 (40)	15.3 (38)	54.4 (136)	55.0 (137)	11.2 (28)	6 (15)	34 (13.6%)	22 (8.8%)

(n)=number of boxes

Annex 5 – Maintenance Requirements

Box N.	Nest Box Name	Zone	Season	Signs of use	Fauna	Comments	Maintenance Action
10	NBA.MB.10	Zone A	Summer	Insect nest			Clean insect nests
10	NBA.MB.10	Zone A	Winter	Wasp Nest			Clear Wasp nest
15	NBA.PL.04	Zone A	Winter	Bark and leaf nest		Branch blocking access	Reposition as growing branches will make inaccessible
17	NBA.PL.06	Zone A	Winter	Bark and leaf		Scats in corner	Reposition as growing branches will make inaccessible
26	NBB.MB.02	Zone B	Winter	Unknown		Could not open. Needs repositioning	Reposition as inaccessible for monitoring.
38	NBC.PO.02	Zone C	Winter	Bees	Bees		Clear bees
43	NBC.SG.02	Zone C	Winter	Bees	Bees		Clear bees
61	NBD.SG.02	Zone D	Winter	Conical leaf nest and old wasp nests			Clear Wasp nest
64	NBE.COSO.02	Zone E	Winter	Little leaf litter	Wasp		Clear Wasp nest
70	NBE.PL.02	Zone E	Summer	Ants	Ants		Clear ants
87	NBF.PO.03	Zone F	Winter	Leaf nest			Loose Lid - possibly replace
91	NBF.PO.08	Zone F	Summer	Ants	Ants		Clear ants
92	NBF.PO.09	Zone F	Summer	Ants	Ants		Clear ants
95	NBF.SF.03	Zone F	Summer	Leaf drey - glider + pest		Mud wasp nest	clean wasp nest
95	NBF.SF.03	Zone F	Winter	Leaf nest			Replace box
100	NBF.SG.02	Zone F	Summer	Eucalypt leaf drey - glider			Loose on tree
100	NBF.SG.02	Zone F	Winter	Leaf Nest	Bees	Bee Hive	Clear bee hive
103	NBF.SG.05	Zone F	Summer	Ants	Ants & eggs	Insect silk in opening	Clear ants
108	NBG.PL.01	Zone G	Summer	Pest	BEES	Bee hive	Yes
116	NBG.SG.02	Zone G	Summer	Pest	Honeybee or wasp		Remove honeycomb
150	NBJ.LG.04	Zone J	Summer	Broken up bark and leaves + Wasp/insect material		Wasp/insect material	Clear wasp/insect
151	NBJ.LG.05	Zone J	Summer	Bark and leaf fragments		Hanging forward at angle	Re-attach vertically
156	NBJ.PL.01	Zone J	Summer	Bee honeycomb and leaves			Remove wax
158	NBJ.PO.01	Zone J	Summer	Ants		Ants and eggs	Clear ants
165	NBJ.SF.05	Zone J	Summer	Dry leaves + mud wasp nest		Mud wasp nest	Clear wasp nest
171	NBJ.SG.05	Zone J	Summer	Dry leaves + loose honeycomb		Loose honeycomb	Clear honeycomb
179	NBK.PL.03	Zone K	Summer	Old eucalypt leaves and honeycomb			Remove honeycomb
188	NBK.SG.04	Zone K	Summer	Old brown eucalypt leaves		Honeycomb on lid	Remove honeycomb
189	NBK.SG.05	Zone K	Summer	Fresh eucalypt leaf nest - probable glider + ants	Ants		Clear ants
190	NBK.SG.06	Zone K	Summer	Ants	Ants		Clear ants
192	NBL.CO.01	Zone L	Summer	Occupied	Probable Common Brushtail Possum		Reposition to allow lid opening

Box N.	Nest Box Name	Zone	Season	Signs of use	Fauna	Comments	Maintenance Action
192	NBL.CO.01	Zone L	Winter	None			Lid stuck closed
194	NBL.LG.02	Zone L	Winter	Wasp nest	Wasp		Clear Wasp nest
201	NBL.MB.03	Zone L	Summer	Pest	Insect nest		Clear insect nest
211	NBL.PO.04	Zone L	Summer	Ants	ANTS		Clear ants
211	NBL.PO.04	Zone L	Winter	Bees/Wasps		Infested	Replace box
212	NBL.PO.05	Zone L	Winter	Leaf litter			Lid falling off - possibly replace
213	NBL.SF.01	Zone L	Summer	Ants	Full of ants		Clear ants
213	NBL.SF.01	Zone L	Winter	Infested	Ants		Clear ants
218	NBL.SG.02	Zone L	Summer	Dry leaves and honeycomb			Clear honeycomb
230	NBM.PL.05	Zone M	Summer	Ants	Ants		Clear ants
230	NBM.PL.05	Zone M	Winter	Ants	Ants		Clear ants
233	NBM.PO.03	Zone M	Winter	Ants	Ants		Clear ants
236	NBM.PO.06	Zone M	Summer	Ants	Ants		Clear ants
238	NBM.SF.03	Zone M	Summer	Ants	Possible ants nest		Clear ants
239	NBM.SF.04	Zone M	Summer	Ants	Ants		Clear ants
242	NBM.SF.07	Zone M	Summer	Leaves - possible glider nest + ants	Ants & eggs		Clear ants
243	NBM.SF.08	Zone M	Summer	Ants	Ants		Clear ants
243	NBM.SF.08	Zone M	Winter	Ants	Ants		Clear Ants
246	NBM.SG.04	Zone M	Summer	Ants	Ants		Clear ants
247	NBM.SG.05	Zone M	Summer	Leaves - probable glider			Yes - box hanging forward
250	NBM.SG.08	Zone M	Summer	Ants	Ants & eggs		Clear ants
250	NBM.SG.08	Zone M	Winter	Ants	Ants		Clear ants
252	NBF.COSO.02	Zone F	Summer	None			Free lid to open fully

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Appendix E Aerial Crossing Structures



Aerial Crossing Monitoring 2017

Frederickton to Eungai Pacific Highway Upgrade

Prepared for Roads and Maritime Services

January 2018

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Project Manager: Radika Michniewicz

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Radika Michniewicz	R0		21/12/17
Radika Michniewicz	R1		30/01/18

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Cover photograph: Sugar Glider on median glider pole at site 2 (Left), Sugar Glider on rope canopy bridge at site 3 (middle), Feathertail Glider on eastern glider pole at site 1 (right).

Executive summary

Context

This report documents the first of three monitoring cycles for the aerial crossing structures, as required by the Frederickton to Eungai (F2E) Ecological Monitoring Program (EMP, RMS 2016).

Aims

The aim of this report is to summarise the methods and results of the autumn and spring 2017 monitoring and determine if performance measures have been met, as per the EMP.

Methods

In accordance with the EMP, each of the three aerial crossing zones was monitored in autumn and spring of 2017. Monitoring included the use of automated cameras for a period of 60 consecutive days and arboreal tree trapping (20 traps at each zone) was undertaken in residual habitat adjacent to each crossing zone (10 traps either side of the carriageway) over four consecutive nights in autumn and spring.

Key results

- Remote cameras detected three glider species using the aerial crossings, including the Feathertail Glider, Sugar Glider and the threatened Yellow-bellied Glider.
- Gliders were detected on the median glider poles at all three sites, indicating complete crossing of the road at each of the three sites.
- The threatened Brush-tailed Phascogale was also detected on a glider pole.
- Site 3 canopy rope crossing was the only rope crossing of the three installed used by arboreal mammals. Species recorded were the Sugar Glider and Feathertail Glider.
- Complete crossings were not detected on canopy rope crossings which is likely due to gliding behaviour of the detected species.
- Four species of native fauna were captured and six individuals (four Sugar Gliders and two Brushtail Possums) were tagged during the arboreal trapping. There were no recaptures during arboreal trapping and no tagged animals were therefore re-captured on the opposite side of the carriageway to which they were caught.
- There were no records of road kill glider species from the 2016/2017 road kill monitoring results.

Conclusions

Glider poles. Indicators of success in relation to successful complete crossings of the glider poles by glider species and use of eastern and western poles have been met, while detection of successful crossings by animals using mark-recapture techniques was not successful, i.e. animals captured and tagged on one side of the carriageway were not subsequently trapped on the opposite side of the carriageway. Neither sign of unsuccessful mitigation has been met for the glider crossings as gliders were detected on all median poles and gliders were not recorded as road strike.

Rope bridges. While arboreal fauna were observed on the rope bridges, successful, complete crossings were not detected using remote cameras or recaptures during arboreal trapping. As such, neither indicator of success has been met for canopy rope bridges. However, gliders were the only species detected on the rope bridges and as gliders may arrive and depart from the rope bridge at an undefined point, they may do so without triggering the second camera.

Management implications

A number of recommendations have been made in relation to contingency measures provided within the EMP to address reasons why the mitigation measures may have been unsuccessful. Notably, consideration should be given to downloading photographic data on a regular basis in an effort to capture additional crossings that may occur outside of the 60 day monitoring period.

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1. Introduction

1.1 Context

As part of Frederickton to Eungai (F2E) Pacific Highway Upgrade Project (the Project), Roads and Maritime Services (Roads and Maritime) have implemented an Ecological Monitoring Program in accordance with the Minister for Planning's Condition of Approval (MCoA) No. 3.1. This Ecological Monitoring Program (RMS 2016) (hereafter referred to as the EMP) combines the approval conditions provided within the Ministers Conditions of Approval (MCoA) and Statement of Commitments (SoC), and defines the mitigation and offsetting requirements for threatened species and ecological communities impacted by the Project.

Aerial crossings have been installed to reduce the impacts on fauna, facilitate movement and maintain connectivity for existing glider/arboreal mammal populations (RMS 2016). These structures are to be monitored to assess their effectiveness.

1.1.1 Monitoring framework

The EMP states the following regarding monitoring:

"It is proposed that monitoring of the glider crossings be undertaken in order to provide long term insights into the mitigation effectiveness once the carriageway becomes operational. With this in mind, monitoring would commence 6 months after the structures have been installed and focus on a 4 week sampling period in autumn and spring in 2017, 2018, and 2019, after which the need for further monitoring would be reviewed in consultation with EPA"

This report represents the first report for the monitoring program and includes results from *autumn and spring 2017*

This report represents the first of three monitoring cycles required by the EMP for aerial crossing monitoring.

1.1.2 Baseline data

The EMP provides the following background information for the baseline data:

"Table A3 provides results of surveys in the vicinity of the three nominated aerial crossing locations. Yellow-bellied Glider has been recorded at or near each of the three crossing locations as have Brush-tailed Phascogale and other common arboreal fauna including Common Brushtail Possum, Sugar Gliders and Feathertail Glider".

Table A3 is provided in the original EMP (Lewis 2013) and presents the results of systematic surveys for the Kempsey to Eungai Environmental Assessment (Lewis 2005).

1.1.3 Purpose of this report

This report complies with the monitoring requirements described within the approved EMP and details the findings of the first monitoring event.

The aims of this report are to summarise the methods and results of the autumn and spring 2017 monitoring and determine if performance measures have been met, as per the EMP.

1.2 Performance measures

The EMP specifies the performance indicators for the aerial crossing structures.

Indicators of success for the glider poles would include one or more of the following:

- Evidence of use by any glider species using the median pole.
- Photographic evidence of a glider using both the eastern and western poles.
- One or more gliders with left ear tag/notch occurring on the western side of the carriageway and fauna with right ear tag/notch occurring on the eastern side of the carriageway.

Signs of the glider poles being unsuccessful will be based on the:

- Absence of gliders being recorded using the median pole of other evidence of complete crossings.
- Unacceptable levels of road strike (presence of deceased individuals during each sampling period for either year). For example, recording one or more gliders as road strike in both monitoring seasons would be considered as unsuccessful and require contingency measures.

Indicators of success for the rope canopy bridges would include one or more of the following:

- Photographic evidence of any arboreal species using both sides of the rope ladder to indicate a successful passage.
- One or more arboreal species with left ear tag/notch occurring on the western side of the carriageway and arboreal fauna with right ear tag/notch occurring on the eastern side of the carriageway.

Signs of the canopy rope bridges being unsuccessful will be based on the:

- No photographic evidence of arboreal fauna successfully crossing the rope bridge or other evidence of complete crossings (i.e. ear tags, notches).
- Unacceptable levels of road strike (presence of deceased individuals during each sampling period for either year). For example, recording one or more gliders as road strike in both the winter and spring would be considered as unsuccessful and require contingency measures.

Note, PIT tagging of captured animals was used in place of ear notching as an alternative (and ethically sounder) approach to identifying individual animals during the mark-recapture component of the monitoring. This change in methodology was undertaken in consultation with RMS and the EPA.

1.3 Monitoring timing

As per the EMP, monitoring will be undertaken in autumn and spring of 2017, 2018 and 2019.

1.4 Reporting

Annual reporting of monitoring results will outline:

- A description of the monitoring methodology employed.
- Results, including field data, of the monitoring surveys.
- A discussion of the results, including how the results compare against key performance criteria.
- The need for any corrective actions/contingency measures and any general recommendations.

All reports prepared under the EMP will be submitted to the Director General of the NSW Department of Planning and Environment and the NSW Environment Protection Authority (EPA).

1.5 Limitations

The following limitations to the monitoring procedure were encountered:

- The camera detection system is designed to maximise the likelihood that any animal using the structures is photographed (i.e. the cameras are fitted with motion detectors triggered to take photographs as animals pass by and the glider poles also have collars to force the animals through a single gap where the camera is trained). However, the highly mobile nature of gliders may result in their arrival on the structures at a variety of locations, all of which cannot be captured by the cameras. As a result complete passage across the road may not always be captured. This limitation applies to both glider poles and rope bridges.

2. Survey methods

2.1 Survey sites

Three aerial crossing zones (hereafter Sites 1- 3) are specified in the EMP. Site 1 and 2 each have a single canopy rope bridge and a set of glider poles consisting of a pole on each opposing road verge and a single median pole. Site 3 has a single canopy rope bridge and a single glider pole crossing, consisting of two median poles and one road verge pole, due to existing suitable trees to glide from/to on the opposing road verge. The location of each crossing structure is provided in Figure 1.

2.2 Survey method

2.2.1 Remote cameras

Automated cameras were installed at the top of each crossing structure pole, i.e. a single camera was installed on each glider pole and a single camera was installed at each end of the canopy rope bridge. Customised surveillance systems were installed at glider crossings and canopy rope bridges using BuckEye Cam X7D Covert IR wireless surveillance cameras (minimum response time 200 milliseconds) and standard antennae. Cameras were mounted on a customised adjustable camera mount or strut. Power is provided via a solar panel and extension power cable connected to the battery housing near ground level, which is mounted on each pole. Each glider pole was fitted with a collar to direct animals toward the camera in order to capture their image. Rope bridges were fitted with an external dual active infra-red rope bridge sensor to trigger cameras. All cameras were calibrated for short focus and reduced infrared output to maximise species identification. These devices were specifically designed by Faunatech Pty Ltd for these crossing structures. Images were downloaded wirelessly to ground level via X-Manager software installed on a laptop.

Sixty day monitoring periods were as follows:

- *Autumn 2017: 28th March - 26th May.*
- *Spring 2017: 2nd September - 31st October.*

2.2.2 Arboreal trapping

Trapping was undertaken in residual habitat adjacent to the crossing zones over four nights. A total of 20 traps were deployed at each crossing zone; 10 traps were placed on either side of the carriageway and grouped around the crossing structure poles (i.e. the 10 traps were distributed between the canopy rope bridges and glider pole crossings where these structures were not immediately adjacent to each other). Figures 2 to 4 show the trap locations. A range of arboreal trap types were used including pipe, Elliott and cage traps (Table 1). Details recorded of captured individuals included species, weight, gestation and sex. Larger species that were captured (i.e. any arboreal marsupial greater than 100 grams in weight) were implanted with a passive integrated transponder (PIT) microchip to allow for individual identification. As mentioned previously, this was used in place of ear notching to allow identification of individual animals.

Traps were baited with a mixture of rolled oats and peanut butter and positioned on brackets two metres above the ground. The host tree was sprayed with a mixture of honey water above and below the trap as an additional attractant. The traps were left operating over four consecutive nights. Traps were checked within two hours of sunrise each morning, re-baited and re-sprayed with honey water.

Arboreal trapping survey periods were as follows:

- *Autumn 2017*: 3rd - 7th April.
- *Spring 2017*: 18th - 22nd September.

Table 1: Trapping effort

Trap type	Site 1		Site 2		Site 3	
	Autumn	Spring	Autumn	Spring	Autumn	Spring
Elliott B	8	8	5	6	6	6
Cage	4	4	5	4	4	4
Pipe	8	8	10	10	10	10

3. Results

Detailed survey results for the autumn and spring monitoring are presented in Annex 1 and Annex 2.

3.1 Remote cameras

Combined results from autumn and spring for the glider crossings and canopy rope bridges are presented below in Table 2 and Table 3. A summary of results for each site is provided in Table 4, Table 5 and Table 6. It is noted that due to the downloading of cameras over a number of days (the time required per camera varies from 8 to 48 hours), some photo observations of animals were made outside of the 60 day period. These observations have been included in the results.

3.1.1 Glider crossings

A successful crossing was considered as the detection of an individual using the median pole. Photographic data was also analysed for the detection of the same species within rapid succession on both the western and eastern road verge poles at Sites 1 and 2 as an indication of a successful crossing.

The Sugar Glider (*Petaurus breviceps*) was detected at Site 1 and 2 using the median glider poles on one occasion. This species was also photographed using both the eastern and western poles at Site 2, but on two separate occasions. The Feathertail Glider (*Acrobates pygmaeus*) was observed frequently using the eastern and western poles at Sites 1 and 2, and was detected on the median poles at Site 2 and 3. On one occasion (28/3/2017) at Site 2 a Feathertail Glider was detected on the western pole at 22:10 and then on the eastern pole at 22:12. It is considered that this is likely to be the same individual.

Two threatened species were detected on the glider poles. The Yellow-bellied Glider (*Petaurus australis*) was detected on the western pole at Site 1 and the Brush-tailed Phascogale (*Phascogale tapoatafa*) was observed moving in a downwards direction on the eastern pole at Site 2.

Table 2: Fauna use of glider poles

Species	Site 1			Site 2			Site 3		
	Eastern	Median	Western	Eastern	Median	Western	Eastern	Median	Median2
Feathertail Glider	✓ (4)		✓ (8)	✓ (7)	✓ (3)	✓ (8)	✓ (21)	✓ (1)	✓ (5)
Sugar Glider		✓ (1)	✓ (2)	✓ (1)	✓ (1)	✓ (1)			
Yellow-bellied Glider			✓ (1)						
Unknown mammal			✓ (1)	✓ (2)				✓ (1)	
Brush-tailed Phascogale				✓ (1)					

(n) = number of times detected.

3.1.2 Canopy rope bridges

As for the glider crossings, photographic data was analysed for the detection of the same species within rapid succession on both the western and eastern sides of the crossing as an indication of a successful crossing.

Two arboreal mammal species, the Sugar Glider and Feathertail Glider, were detected using the Site 3 canopy rope crossing. Photographic time stamps did not indicate a complete crossing. As gliders may arrive and depart from the rope bridge at an undefined point, they may do so without triggering the second camera. Arboreal mammals were not detected using Site 1 and Site 2 canopy rope bridges.

Table 3: Fauna use of rope canopy bridges

Species	Site 1		Site 2		Site 3	
	Eastern	Western	Eastern	Western	Eastern	Western
Feathertail Glider					✓ (2)	✓ (4)
Sugar Glider						✓ (2)
Unknown mammal					✓ (2)	
Small Bird				✓ (1)		
<i>Corvus</i> spp.	✓ (48)	✓ (17)	✓ (17)	✓ (53)		
Kookaburra				✓ (1)		

(n) = number of times detected.

Table 4: Site 1 remote camera records 2017

Camera	Autumn	Spring	Detection frequency (mammals)
GP1 East	Feathertail Glider (3)	Feathertail Glider (1)	4
GP1 Med	Sugar Glider (1)		1
GP1 West	Sugar Glider (1) Feathertail Glider (6) Probable Yellow-bellied Glider (1)	Unknown Glider (1) Feathertail Glider (2)	11
RB1 East	<i>Corvus</i> spp. (Ravens) (46)	<i>Corvus</i> spp. (Ravens) (2)	0
RB1 West	<i>Corvus</i> spp. (Ravens) (16)	<i>Corvus</i> spp. (Ravens) (1)	0

Table 5: Site 2 remote camera records 2017

Camera	Autumn	Spring	Detection frequency (mammals)
GP2 East	Feathertail Glider (7) Brush-tailed Phascogale (1) Unknown Glider (1)	Unknown Glider (1) Sugar/Squirrel glider (1) Feathertail Glider (1)	12
GP2 Med	Sugar Glider (1) Tail – likely Feathertail Glider (2)	Feathertail Glider (1)	4
GP2 West	Feathertail Glider (7)	Feathertail Glider (1) Sugar Glider (1)	9
RB2 East	<i>Corvus</i> spp. (Ravens) (14)	<i>Corvus</i> spp. (Ravens) (3)	0
RB2 West	<i>Corvus</i> spp. (Ravens) (53)	Small bird (1) Kookaburra (1)	0

Table 6: Site 3 remote camera records 2017

Camera	Autumn	Spring	Detection frequency (mammals)
GP3 East	Feathertail Glider (19)	Feathertail Glider (2)	21
GP3 Med	Tail – likely Feathertail Glider (1)	Tail – unknown (1)	2
GP3 Med2	Feathertail Glider (4)	Feathertail Glider (1)	5
RB3 East	Small mammal (2)	Feathertail Glider (1)	3
RB3 West	Sugar Glider (2) Feathertail Glider (4)		6

3.2 Arboreal trapping

Five species were captured in arboreal traps during autumn and spring monitoring, comprising:

- Common Brushtail Possum (*Trichosurus vulpecula*)
- Black Rat (*Rattus rattus*)
- Sugar Glider
- Bush Rat (*Rattus fuscipes*)
- Brown Antechinus (*Antechinus stuartii*)

A total of six animals were implanted with PIT tags. This included two Brushtail Possums and four Sugar Gliders. The Brushtail Possums were captured at rope bridge 1 and site 2 (rope bridge and glider crossing adjacent), both on the western side of the carriageway. Sugar Gliders were captured at rope bridge 1 and glider pole 1 on the eastern side and at site 2 on the western side. There were no recaptures within each trapping event or between autumn and spring that would indicate successful road crossings by an individual. Trapping results are provided in Annex 2.

3.3 Road kill

Road kill monitoring results are presented in the Frederickton to Eungai Fauna Underpass and Associated Fauna Fencing Monitoring report 2016/2017 (Niche 2017). While road strike monitoring was not part of aerial crossings monitoring, the EMP requires specific reporting on the presence of road strike gliders at or in vicinity of aerial crossings. Data presented within Niche 2017 did not show any records of road kill glider species from the 2016/2017 road kill results.

3.4 Comparison with baseline data

Baseline surveys detected a number of arboreal and scansorial mammal species near some or all aerial crossing locations, including: Brush-tailed Phascogale, Yellow-bellied Glider, Sugar Glider, Greater Glider (*Petauroides volans*), Feathertail Glider, Common Ringtail Possum (*Pseudocheirus peregrinus*), Common Brushtail Possum, Mountain Brushtail Possum (*Trichosurus cunninghami*), Bush Rat, and Brown Antechinus.

Of these 10 species, four (the Yellow-bellied Glider, Sugar Glider, Feathertail Glider and Brush-tailed Phascogale) have been observed using the aerial crossing structures and another four (the Common Brushtail Possum, Sugar Glider, Brown Antechinus and Bush Rat) were recorded during trapping surveys. Three of the four glider species previously recorded (with the exception of the Greater Glider) were detected on the glider crossings and canopy rope bridges, with a noticeable absence of possum species using canopy rope bridges.

4. Discussion

4.1 Performance measures

A summary of the autumn and spring 2017 survey results in relation to the performance indicators is provided in Table 7 to Table 10.

Table 7: Indicators of success for the glider poles

Indicators of success	Discussion
Evidence of use by any glider species using the median pole.	This performance indicator of success has been met. The median poles of all three glider crossings were used by at least one glider species.
Photographic evidence of a glider using both the eastern and western poles.	This performance indicator of success has been met. Gliders have been detected on the eastern and western poles at all three sites. Photographic evidence showing use of both poles in a complete crossing is limited to a single occurrence at Site 2.
One or more gliders with left ear tag/notch occurring on the western side of the carriageway and fauna with right ear tag/notch occurring on the eastern side of the carriageway.	This performance indicator of success has not been met. Implantation of PIT microchips was implemented as an alternative method to ear notching to identify individual animals in consultation with RMS and the EPA. There were no captures of individually marked animals on both sides of the road. Contingency measures to be considered in response to this are discussed below.

Table 8: Signs of the glider poles being unsuccessful

Signs of the glider poles being unsuccessful	Discussion
Absence of gliders being recorded using the median pole or other evidence of complete crossings.	This sign of unsuccessful mitigation has not been met. The median poles of all three glider crossings were used by at least one glider species.
Unacceptable levels of road strike (presence of deceased individuals during each sampling period for either year). For example, recording one or more gliders as road strike in both monitoring seasons would be considered as unsuccessful and require contingency measures.	This sign of unsuccessful mitigation has not been met. There were no records of road kill glider species from the 2016/2017 road kill monitoring results.

Table 9: Indicators of success for the canopy rope bridges

Indicators of success	Discussion
Photographic evidence of any arboreal species using both sides of the rope ladder to indicate a successful passage.	This performance indicator of success has not been met. No individual has been recorded using both sides of a crossing in rapid succession. Gliders were the only species detected on the rope bridges and as gliders may arrive and depart from the rope bridge at an undefined point, they may do so without triggering the second camera. Site 1 and 2 have shown no evidence of use by arboreal fauna. Contingency measures to be considered in response to this are discussed below.
One or more arboreal species with left ear tag/notch occurring on the western side of the carriageway and arboreal fauna with right ear tag/notch occurring on the eastern side of the carriageway.	This performance indicator of success has not been met. Implantation of PIT microchips was implemented as an alternative method in consultation with RMS and the EPA. There were no captures of individually marked animals on both sides of the road. Contingency measures to be considered in response to this are discussed below.

Table 10: Signs of the rope bridges being unsuccessful

Signs of the rope bridges being unsuccessful	Discussion
<p>No photographic evidence of arboreal fauna successfully crossing the rope bridge or other evidence of complete crossings (i.e. ear tags, notches).</p>	<p>This sign of unsuccessful mitigation has been met. No individual has been recorded using both sides of a crossing in rapid succession. Contingency measures to be considered in response to this are discussed below.</p>
<p>Unacceptable levels of road strike (presence of deceased individuals during each sampling period for either year). For example, recording one or more gliders as road strike in both the winter and spring would be considered as unsuccessful and require contingency measures.</p>	<p>This sign of unsuccessful mitigation has not been met. There were no records of road kill glider species from the 2016/2017 road kill monitoring results.</p>

5. Recommendations

5.1 Contingency measures

The EMP lists potential problems and contingency measures for various components of the monitoring program. Those that are considered to be relevant to the aerial crossing monitoring program are listed and discussed in Table 11.

Table 11: Contingency measures

Potential Problem	Contingency Measure proposed in EMP	Discussion of proposed measure
No fauna recorded using the poles or rope ladder canopy bridges	<ul style="list-style-type: none"> Review other monitoring data. Review planting schedules/status of vegetation bordering the poles and/or rope ladder canopy bridges. Review monitoring program and make necessary adjustments. Consider placing lead/lure ropes from neighbouring trees to the poles and/or rope ladder canopy bridges. 	<p>These contingency measures are considered relevant.</p> <p>Arboreal mammals have not been detected using canopy rope bridges at Site 1 and 2.</p> <p>Successful crossings of canopy rope bridges have not been confirmed.</p> <p>Recaptures have not been made, therefore there is no evidence of tagged gliders crossing the carriageway.</p>
No evidence or marked/tagged gliders crossing the carriageway.		
Unacceptable levels of road strike for gliders (>1 during each monitoring event for Year 1, Year 2, Year 3)	<ul style="list-style-type: none"> Review current information of glider pole plane angles. Consider design adjustment that could improve the usability of the poles and/or rope ladder canopy bridges. Review the extent of vegetation in the median. 	<p>These contingency measures are not considered relevant.</p> <p>There were no records of road kill glider species from the 2016/2017 road kill monitoring results.</p>

5.2 Recommendations

In relation to the relevant contingency measures noted above (Table 11), and performance indicators that have not been met, a number of recommendations have been made in Table 12.

Table 12: Recommendations

Problem identified during 2017 monitoring	Discussion/Recommendation
Arboreal mammals have not been detected using canopy rope bridges at Site 1 and 2.	<ul style="list-style-type: none"> As the cameras have been installed and function continually throughout the year, consideration should be given to downloading photographic data on a regular basis in an effort to capture additional crossings by fauna that may occur outside of the 60 day monitoring period. If this additional data show arboreal fauna to be absent from Site 1 and 2, consideration should be given to placing additional lead/lure ropes from neighbouring trees to the rope ladder canopy bridges. Depending on the proximity of the primary rope ladder pole to adjacent vegetation, additional lead ropes may improve fauna access to the rope ladder.
Successful crossings of canopy rope bridges have not been confirmed.	<ul style="list-style-type: none"> If the additional data is not downloaded/analysed, and 2018 monitoring finds continued absence of arboreal fauna from Site 1 and 2, consideration should be given to placing additional lead/lure ropes from neighbouring trees to the rope ladder canopy rope bridges, as above.
Recaptures of tagged fauna have not been made on either side of the road, therefore there	<ul style="list-style-type: none"> Due to low capture rate of gliders combined with the limited trapping effort, it is considered that this means of identifying successful crossings is unlikely to result in positive outcomes. It is likely that a substantial increase in trapping effort would be required to obtain the necessary micro chipping numbers to provide results based on mark-recapture surveys.

Problem identified during 2017 monitoring	Discussion/Recommendation
<p>is no evidence of tagged gliders crossing the carriageway.</p>	<ul style="list-style-type: none"> It is recommended that the success of these mitigation measures be determined by successful crossings established by a combination of either photographic means and/or tagging, and that the absence of recaptures should not be considered as a sign of unsuccessful mitigation.

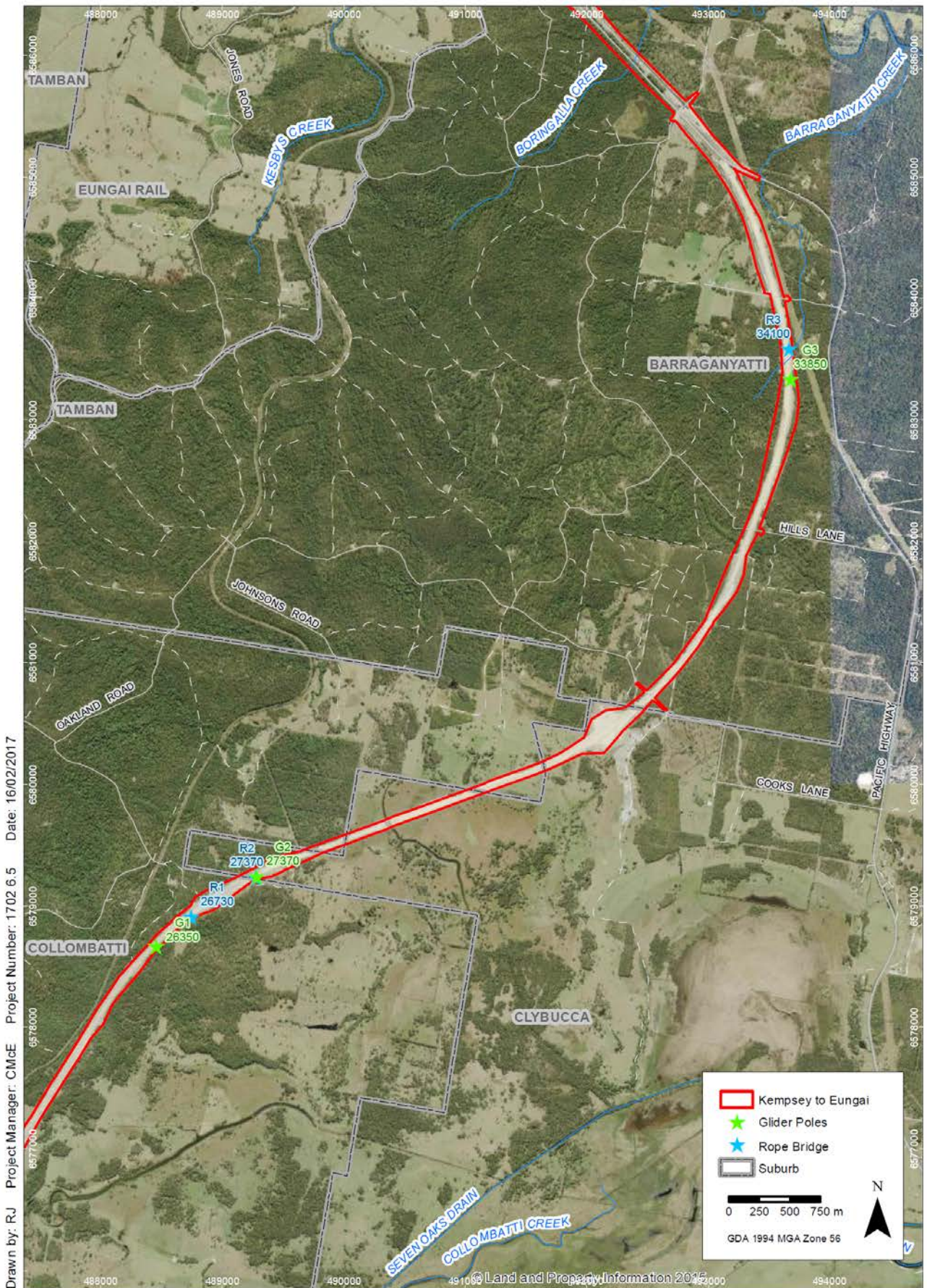
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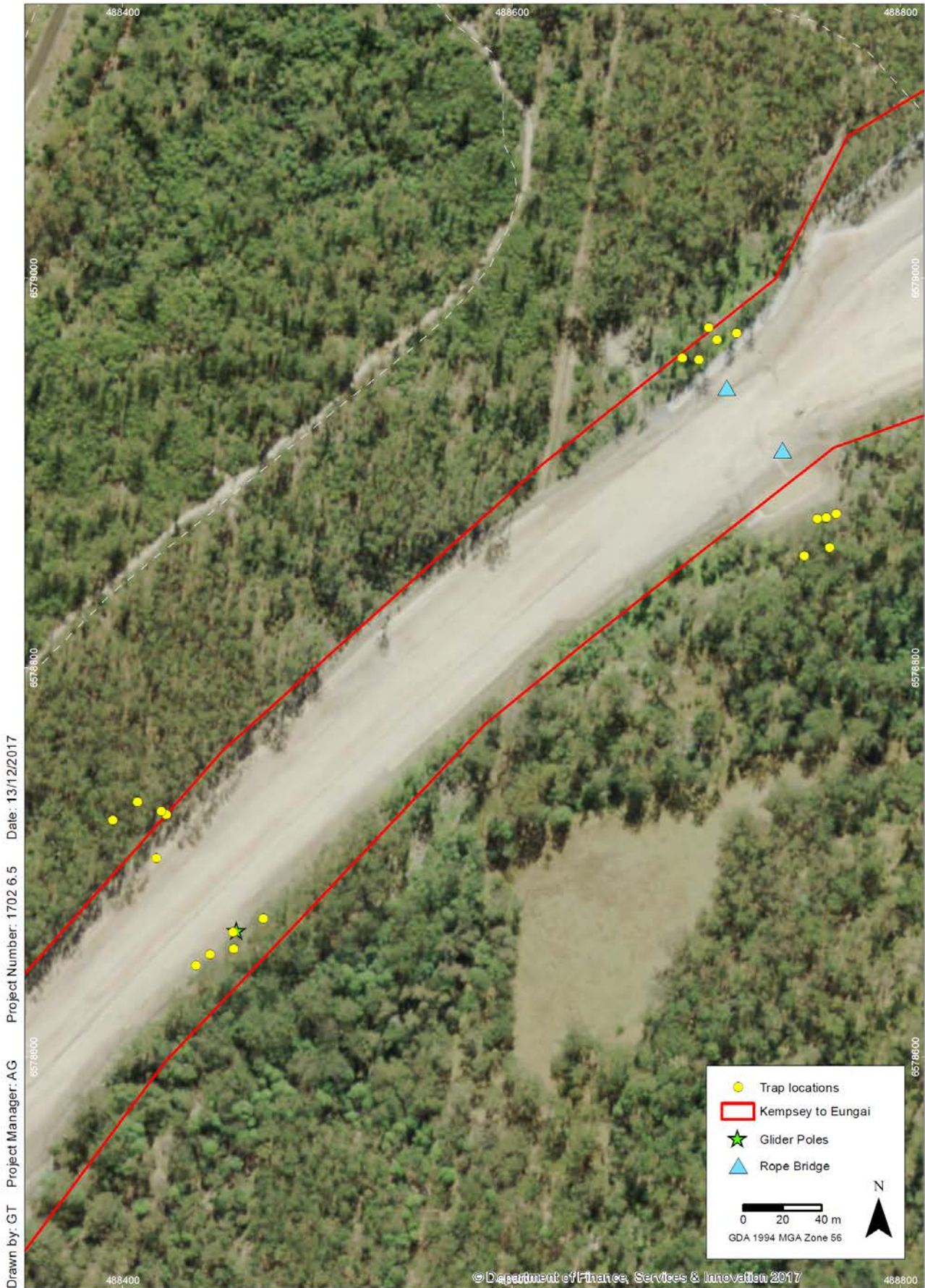
RMS (2016). Frederickton to Eungai Pacific Highway Upgrade Ecological Monitoring Program. Roads and Maritime Update to report prepared by Lewis Ecological Surveys, May 2016.



Location of Aerial Crossings F2E
OH2K PI 6.5 Aerial Crossings

FIGURE 1

Imagery: (c) LPI 2014-09-18



Location of Trapping Zone 1 Aerial Crossings F2E
OH2K PI 6.5 Aerial Crossings

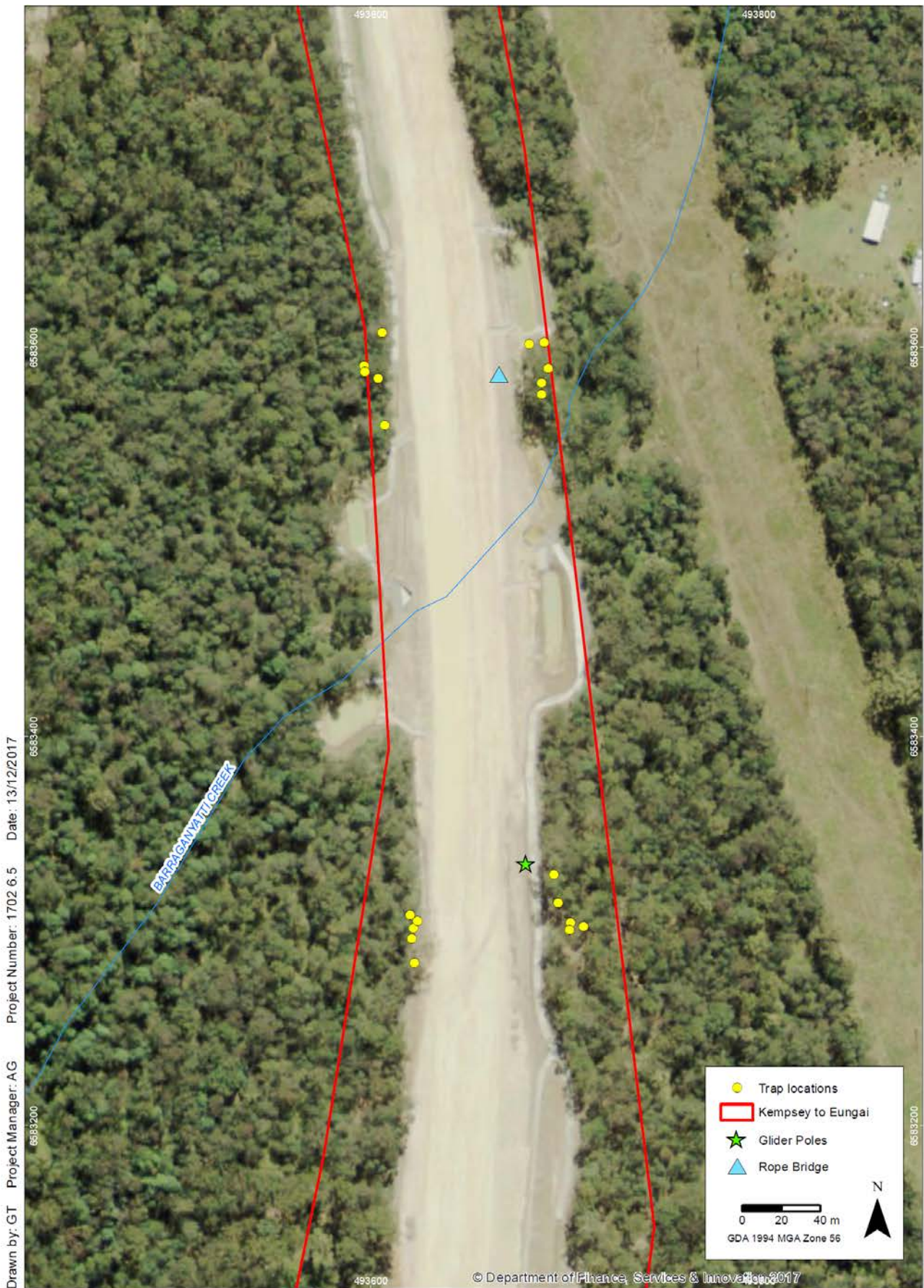
FIGURE 2

Imagery: (c) LPI 2014-09-18



Drawn by: GT Project Manager: AG Date: 13/12/2017 Project Number: 1702.6.5

Location of Trapping Zone 2 Aerial Crossings F2E
OH2K PI 6.5 Aerial Crossings



Location of Trapping Zone 3 Aerial Crossings F2E
OH2K PI 6.5 Aerial Crossings

FIGURE 4

Imagery: (c) LPI 2014-09-18

Annex 1 – Remote Cameras

Table 13: Remote camera records - autumn and spring 2017

Season	Site	Pole ID	Camera	Date	Time	Species	No. Photos
Autumn	1	GP1 East	1	04/05/2017	9:40:00 AM	Feathertail Glider	1
Autumn	1	GP1 East	1	22/04/2017	10:04:18 PM	Feathertail Glider	1
Autumn	1	GP1 East	1	29/04/2017	7:17:51 PM	Feathertail Glider	2
Autumn	1	GP1 Med	2	30/04/2017	8:53:28 PM	Sugar Glider	3
Autumn	1	GP1 West	3	03/04/2017	3:34:27 AM	Tail - likely Sugar Glider	2
Autumn	1	GP1 West	3	22/04/2017	11:50:38 PM	Feathertail Glider	2
Autumn	1	GP1 West	3	23/04/2017	7:37:13 PM	Feathertail Glider	1
Autumn	1	GP1 West	3	25/04/2017	7:43:49 PM	Feathertail Glider	1
Autumn	1	GP1 West	3	26/04/2017	4:11:30 AM	Yellow-bellied Glider	2
Autumn	1	GP1 West	3	29/04/2017	11:49:11 PM	Feathertail Glider	1
Autumn	1	GP1 West	3	08/05/2017	3:33:40 AM	Tail-Feathertail Glider	1
Autumn	1	GP1 West	3	09/05/2017	5:10:55 AM	Tail- Feathertail Glider	1
Autumn	1	RB1 East	4	03/04/2017 - 26/04/2017	Day	<i>Corvus</i> sp.	46
Autumn	1	RB1 West	5	12/04/2017 - 30/04/2017	Day	<i>Corvus</i> sp.	16
Autumn	2	RB2 East	6	19/04/2017 - 31/05/2017	Day	<i>Corvus</i> sp.	14
Autumn	2	RB2 West	7	22/04/2017 - 8/05/2017	Day	<i>Corvus</i> sp.	53
Autumn	2	GP2 East	8	28/03/2017	10:12:13 PM	Feathertail Glider	1
Autumn	2	GP2 East	8	30/03/2017	1:06:17 AM	Feathertail Glider	3
Autumn	2	GP2 East	8	20/04/2017	7:38:30 PM	Feathertail Glider	1
Autumn	2	GP2 East	8	27/04/2017	10:06:42 PM	Feathertail Glider	2
Autumn	2	GP2 East	8	27/04/2017	10:10:07 PM	Feathertail Glider	1
Autumn	2	GP2 East	8	27/04/2017	10:12:54 PM	Feathertail Glider	2
Autumn	2	GP2 East	8	01/05/2017	12:12:42 AM	Unknown Glider	1
Autumn	2	GP2 East	8	07/05/2017	4:22:10 AM	Feathertail Glider	1
Autumn	2	GP2 East	8	27/05/2017	3:27:17 AM	Brush-tailed Phascogale	1
Autumn	2	GP2 Med	9	15/04/2017	7:12:50 PM	Tail – likely Feathertail Glider	1
Autumn	2	GP2 Med	9	16/04/2017	9:21:01 PM	Sugar Glider	3
Autumn	2	GP2 Med	9	24/04/2017	8:47:34 PM	Tail - likely Feathertail Glider	1
Autumn	2	GP2 West	10	28/03/2017	5:12:32 AM	Feathertail Glider	1
Autumn	2	GP2 West	10	28/03/2017	10:10:12 PM	Feathertail Glider	1
Autumn	2	GP2 West	10	04/04/2017	4:15:39 AM	Feathertail Glider	1
Autumn	2	GP2 West	10	20/04/2017	4:30:07 PM	Feathertail Glider	1
Autumn	2	GP2 West	10	05/05/2017	2:07:07 AM	Tail - Feathertail Glider	1
Autumn	2	GP2 West	10	17/05/2017	9:31:10 PM	Feathertail Glider	1
Autumn	2	GP2 West	10	28/05/2017	1:05:29 AM	Tail - Feathertail Glider	1
Autumn	3	GP3 East	11	27/03/2017	8:59:02 PM	Feathertail Glider	1
Autumn	3	GP3 East	11	27/03/2017	10:31:45 PM	Feathertail Glider	3

Season	Site	Pole ID	Camera	Date	Time	Species	No. Photos
Autumn	3	GP3 East	11	27/03/2017	11:17:42 PM	Tail- Feathertail Glider	1
Autumn	3	GP3 East	11	29/03/2017	12:09:54 AM	Tail- Feathertail Glider	1
Autumn	3	GP3 East	11	29/03/2017	12:11:32 AM	Tail- Feathertail Glider	1
Autumn	3	GP3 East	11	29/03/2017	11:32:14 PM	Feathertail Glider	1
Autumn	3	GP3 East	11	29/03/2017	11:37:43 PM	Feathertail Glider	1
Autumn	3	GP3 East	11	31/03/2017	10:35:29 PM	Feathertail Glider	1
Autumn	3	GP3 East	11	22/04/2017	11:56:46 PM	Feathertail Glider	1
Autumn	3	GP3 East	11	25/04/2017	11:58:14 PM	Tail- Feathertail Glider	1
Autumn	3	GP3 East	11	30/04/2017	9:54:36 PM	Tail- Feathertail Glider	1
Autumn	3	GP3 East	11	01/05/2017	6:52:19 PM	Feathertail Glider	1
Autumn	3	GP3 East	11	02/05/2017	9:22:21 PM	Feathertail Glider	1
Autumn	3	GP3 East	11	20/05/2017	6:19:02 PM	Feathertail Glider	1
Autumn	3	GP3 East	11	24/05/2017	12:19:27 AM	Feathertail Glider	1
Autumn	3	GP3 East	11	24/05/2017	3:24:15 AM	Feathertail Glider	1
Autumn	3	GP3 East	11	25/05/2017	9:38:07 PM	Feathertail Glider	1
Autumn	3	GP3 East	11	25/05/2017	10:31:47 PM	Feathertail Glider	1
Autumn	3	GP3 East	11	27/05/2017	9:52:47 PM	Feathertail Glider	1
Autumn	3	GP3 Med	12	24/04/2017	9:33:25 PM	Feathertail Glider	1
Autumn	3	GP3 Med2	13	27/03/2017	9:28:07 PM	Tail- Feathertail Glider	1
Autumn	3	GP3 Med2	13	30/03/2017	4:10:33 AM	Feathertail Glider	2
Autumn	3	GP3 Med2	13	01/04/2017	10:45:09 PM	Tail- Feathertail Glider	1
Autumn	3	GP3 Med2	13	24/04/2017	1:36:27 AM	Feathertail Glider	2
Autumn	3	RB3 East	14	08/04/2017	3:39:53 AM	Small mammal	1
Autumn	3	RB3 East	14	19/04/2017	10:27:00 PM	Small mammal	1
Autumn	3	RB3 West	15	02/04/2017	10:49:52 PM	Feathertail Glider	1
Autumn	3	RB3 West	15	04/04/2017	1:28:02 AM	Feathertail Glider	1
Autumn	3	RB3 West	15	09/04/2017	1:37:01 AM	Feathertail Glider	1
Autumn	3	RB3 West	15	14/04/2017	8:09:11 PM	Feathertail Glider	1
Autumn	3	RB3 West	15	01/05/2017	1:48:44 AM	Sugar Glider	1
Autumn	3	RB3 West	15	01/05/2017	1:49:05 AM	Sugar Glider	1
Spring	1	GP1 East	1	15/10/2017	22:18:38	Feathertail Glider	3
Spring	1	GP1 West	3	18/10/2017	21:53:13	Feathertail Glider	1
Spring	1	GP1 West	3	20/10/2017	1:10:11	Sugar Glider	3
Spring	1	GP1 West	3	20/10/2017	1:24:07	Feathertail Glider	1
Spring	1	GP1 West	3	25/10/2017	3:45:21	Tail - likely Feathertail Glider	1
Spring	1	RB1 East	4	31/08/2017	7:41	<i>Corvus</i> sp.	4
Spring	1	RB1 East	4	01/09/2017	17:06:21	<i>Corvus</i> sp.	1
Spring	1	RB1 West	5	22/09/2017	17:14:46	<i>Corvus</i> sp.	2
Spring	2	RB2 East	6	05/09/2017	16:57:29	<i>Corvus</i> sp.	1
Spring	2	RB2 East	6	16/09/2017	16:55:23	<i>Corvus</i> sp.	5
Spring	2	RB2 East	6	06/10/2017	14:56:12	<i>Corvus</i> sp.	3
Spring	2	RB2 West	7	07/09/2017	7:00:57	Small Bird	1
Spring	2	RB2 West	7	15/10/2017	12:10:26	Kookaburra	17

Season	Site	Pole ID	Camera	Date	Time	Species	No. Photos
Spring	2	GP2 East	8	25/10/2017	1:44:25	Feathertail Glider	3
Spring	2	GP2 East	8	02/11/2017	20:44:15	Sugar Glider	2
Spring	2	GP2 East	8	04/11/2017	21:42:50	Unknown Glider	1
Spring	2	GP2 Med	9	18/09/2017	23:07:31	Feathertail Glider	1
Spring	2	GP2 West	10	21/09/2017	22:40:02	Feathertail Glider	1
Spring	2	GP2 West	10	14/11/2017	23:49:59	Sugar Glider	3
Spring	3	GP3 East	11	28/08/2017	3:02:06	Feathertail Glider	1
Spring	3	GP3 East	11	12/09/2017	23:01:31	Feathertail Glider	1
Spring	3	GP3 Med	12	17/09/2017	2:07:34	Tail - unknown	1
Spring	3	GP3 Med2	13	26/08/2017	2:01:04	Feathertail Glider	1
Spring	3	RB3 East	14	21/10/2017	21:56:04	Feathertail Glider	1

Annex 2 – Arboreal Trapping

Table 14: Arboreal trapping results – autumn and spring 2017.

Date	Survey	Site	East/West of Highway	Trap Type	Species	Recapture (Y/N)	Sex	Weight	Breeding condition	Microchip ID
05/04/2017	Autumn	RB1	West	Cage	Common Brushtail Possum	N	F	1.675 kg	-	0007D26DF3
06/04/2017	Autumn	RB1	East	Cage	Sugar Glider	N	F	80g	not breeding yet	0007634DCC
21/09/2017	Spring	RB1	East	Pipe	Brown antechinus			62g	Nil	
19/09/2017	Spring	GP1	East	Elliot	Sugar Glider	N	F	122g	Nil	0007A106E5
20/09/2017	Spring	GP1	East	Elliot	Sugar Glider	N	F	122g	Nil	000791E9D8
20/09/2017	Spring	GP1	East	Cage	Bush Rat		M	232g	Nil	
22/09/2017	Spring	GP1	East	Cage	Black Rat		M			euthanased
04/04/2017	Autumn	Site 2	West	Cage	Black Rat	N	F	-	-	-
21/09/2017	Spring	Site 2	West	Cage	Common Brushtail Possum	N		2kg+		7635284
21/09/2017	Spring	Site 2	East	Pipe	Antechinus sp.					escaped
22/09/2017	Spring	Site 2	East	Elliot	Sugar Glider	N	F	120g	with young	000791E8D0
22/09/2017	Spring	RB3	West	Pipe	Brown antechinus	N	F		with young	
22/09/2017	Spring	GP3	West	Pipe	Brown antechinus	N	F	55g	with young	

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Appendix F Fauna Underpasses and Fencing



Fauna Underpass and Associated Fauna Fence Monitoring 2016/2017

Frederickton to Eungai Pacific Highway Upgrade

Prepared for Roads and Maritime Services

March 2018

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Cover photograph: Brush-tailed Phascogale site 7 (left), Swamp wallaby site 10 (middle), Northern Brown Bandicoot site 6 (right).

Executive summary

Context

This report documents the results of the first of three monitoring events for underpasses and associated fauna fences and the second of four monitoring events for road kill, as required by the Frederickton to Eungai (F2E) Ecological Monitoring Program (EMP, RMS 2016).

Aims

The aims of this report are to summarise the methods and results of the summer and autumn 2016/2017 monitoring and determine if performance measures have been met, as per the EMP.

Methods

Seven fauna underpass structures were surveyed in accordance with the monitoring method specified in the EMP, specifically:

- Two remote cameras were placed within each underpass and set to record for 60 consecutive days.
- 10 hair tube traps were placed in and around each underpass for 15 consecutive nights.
- Walked surveys of the fence line were conducted for a distance of 250 m north and south of each underpass and on both sides of the carriageway.
- Four weekly road kill surveys were undertaken on the Frederickton to Eungai stretch of the Pacific Highway.

Key results

Representatives of five of the six fauna groups identified in the EMP as fauna potentially impacted by the road and that may benefit from/use the underpasses were recorded using at least one underpass during the 2016/2017 monitoring periods. Each underpass showed use by a range of the nominated fauna groups, with at least three (maximum five) of the six fauna groups being recorded at any one underpass. Frogs were the only fauna group not recorded using the underpasses.

The key target species, the threatened Brush-tailed Phascogale, was recorded at one underpass (underpass 7) during the underpass surveys and incidentally during other monitoring surveys in underpass 10. The majority of other targeted species that were specified for each underpass in the EMP (including the Green-thighed Frog) were not detected.

Road kill has decreased from the initial road opening surveys, however a number of records were within 500 m of the underpasses. Four macropods and one possum were recorded as road kill within 500 m of underpasses, while there were no road kill records of Echidnas, Koalas, Brush-tailed Phascogales or Frogs within 500 m of the underpasses. The majority (66.7%) of road kill records occurred outside fenced areas.

Conclusions

While a number of performance indicators of success have not been met by all or some underpasses (i.e. nominated or target species not being recorded), continued monitoring, as per the EMP, will add to the number of records at each underpass. The data pool of fauna detected using underpasses will increase as more information is acquired over the subsequent monitoring events.

Management implications

A number of recommendations have been made in order to assist the program in meeting its performance measures. Recommendations include extension of the remote camera monitoring period to increase the likelihood of detection of target species and nominated fauna groups.

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1. Introduction

1.1 Context

As part of the Frederickton to Eungai (F2E) Pacific Highway Upgrade Project (the Project), Roads and Maritime Services (Roads and Maritime) have implemented an Ecological Monitoring Program in accordance with the Minister for Planning's Condition of Approval (MCoA) No. 3.1. This Ecological Monitoring Program (hereafter referred to as the EMP) (RMS 2016) combines the approval conditions provided within the Ministers Conditions of Approval (MCoA) and Statement of Commitments (SoC), and defines the mitigation and offsetting requirements for threatened species and ecological communities impacted by the Project.

Fauna underpasses and fauna fencing were installed to reduce the impacts of the Project on fauna. Underpasses were designed to facilitate fauna movement across the road and are to be monitored to assess their use in maintaining connectivity, as required by the EMP.

1.1.1 Monitoring framework

The EMP states the following regarding monitoring:

"It is proposed that monitoring of the fauna underpasses and associated fauna fencing be undertaken in order to provide long term insights into the mitigation effectiveness once revegetation and landscaping efforts have developed sufficient cover. Monitoring would commence when the upgrade becomes operational and be undertaken for 4 weeks during early summer 2016, late autumn and early summer in 2017 and 2018 as well as during late autumn 2019. After the conclusion of this monitoring the need for further monitoring would be reviewed in consultation with EPA".

In addition, the EMP specifies that monitoring of road kill fauna would occur within two months of the road opening, with additional road kill surveys undertaken as part of the underpass and associated fauna fence monitoring. As the specified timing did not align with the road opening, a road kill survey was undertaken for the first 21 days of the Project being opened to the public, as specified in the original EMP (Lewis 2013).

To date, these monitoring events have been reported as follows:

- *Road opening 21 day road kill monitoring:* Niche 2016
- *Early summer 2016 and late autumn 2017:* current report

The 2016/2017 monitoring therefore represents the first of three monitoring events for underpasses and associated fauna fences and the second of four monitoring events for road kill.

1.1.2 Baseline data

The EMP provides the following background information for the baseline data:

"The baseline data has been obtained from systematic surveys undertaken as part of the Environmental Assessment for the Kempsey to Eungai Project (Lewis 2005; Parson Brinkerhoff 2006)."

The baseline data was used to class fauna recorded at or near (<1 km) underpass locations and determine which fauna underpasses were to be monitored as part of the EMP. Seven of the thirteen fauna underpasses were identified as most suitable for monitoring and the fauna groups/species recorded at these locations are shown in Table 1.

Construction monitoring of road kill was not undertaken, as such baseline road kill data is not available.

Table 1: Fauna classes previously recorded at/near monitored underpass locations (extracted from Table 3-4 of EMP).

Monitoring Species/Group	6	7	10	12	13B	14	15
Frogs	√	√	√	√	√	√	√
Reptiles	√	√	√	√	√	√	√
Small Ground Dwelling Mammals (Antechinus, Rodents, Bandicoots)	√		√	√	√	√	√
Echidna	√		√	√	√	√	√
Possums	√	√	√	√	√	√	√
Macropods (Swamp Wallaby, Red-necked Wallaby, Eastern Grey Kangaroo)	√	√	√	√	√	√	√
Brush-tailed Phascogale*	√		√	√	√	√	√

√ = presence, * = key target species.

1.1.3 Purpose of this Report

This report complies with the monitoring requirements described within the EMP and details the findings of the first monitoring event for underpasses and associated fauna fences and the second road kill monitoring event.

The aims of this report are to summarise the methods and results of the summer 2016 and autumn 2017 monitoring and determine if performance measures have been met, as per the EMP.

1.2 Performance measures

The EMP specifies the performance indicators for the underpasses and associated fauna fences, as below.

Indicators of success for the fauna underpass and associated fencing monitoring includes:

- Use of fauna underpass by a range of the nominated indicator species.
- Use of the fauna underpass by key target species.
- Use by fauna with low dispersal abilities.
- Low rate of fauna road strike.
- No breaches in the fauna fence.

The EMP specifies that the “degree of success of each underpass will be determined by the complete passage of one or more individuals from a range of the six fauna groups previously recorded in that area” (Table 1).

The EMP also specifies that “the degree of success of the floppy top fauna fencing will be determined by the absence of specific road struck fauna including Echidna, Koala, Possums (Common Brushtail, Common Ringtail) and macropods (Swamp Wallaby, Red-necked Wallaby, Eastern Grey Kangaroo) on the highway carriageway in the immediate vicinity (i.e. <500 m) of the fauna underpasses. Where phascogale fencing has been installed, the degree of success will be based on the absence of road killed Brush-tailed Phascogale and other scansorial fauna (i.e. Antechinus). Similarly, for frog fencing, its success will be based on the absence of Green-thighed Frog fence breaches/road strike.”

1.3 Monitoring timing

As per the EMP, a road kill survey was undertaken once the road opened to traffic in 2016 (17 May 2016 to 7 June 2016 inclusive) and underpass and fauna fence monitoring was undertaken early in the summer of 2016/2017 and late autumn 2017. Fauna underpass, fauna fence and associated road kill surveys will subsequently be undertaken early in the summer of 2017/2018, late autumn 2018 and early in the summer of 2018/2019, and in late autumn in 2019.

1.4 Reporting

Annual reporting of monitoring results includes:

- A description of the monitoring methodology employed.
- Results, including field data, of the monitoring surveys.
- A discussion of the results, including how the results compare against key performance criteria.
- The need for any corrective actions/contingency measures and any general recommendations.

All reports prepared under the EMP will be submitted to the Director General of the NSW Department of Planning and Environment and the NSW Environment Protection Authority (EPA).

1.5 Limitations

The following limitations to the monitoring procedure were encountered:

- Due to their small size and cryptic nature, frogs and smaller reptiles are difficult to detect within the underpasses using the current survey methodology and thus if present, may have gone undetected.
- Identification and detection of road kill was limited to what can be observed whilst travelling at 80km/hr as it was not considered safe to stop on the operational highway. As such:
 - Some road kill fauna were identified to the vertebrate group level only.
 - Some records were classified as 'unknown' as road kill fauna could not be identified as a result of extensive collision damage.
 - It is possible that small fauna such as frogs, snakes, small mammals and birds have been under counted as small-sized road kill fauna have the potential to be partially or wholly removed by scavenger animals, resulting in impossible identification from the vehicle.

2. Survey methods

2.1 Survey sites

The location of the seven monitored underpasses are shown in Figure 1 and are described, including targeted species, in Table 2.

Table 2: Monitored underpasses (taken from Table 3-3 of the EMP)

Underpass	Type	Targeted species	Fauna fence
6	Combined drainage and fauna underpass	Brush-tailed Phascogale*	Standard and Phascogale fence
7	Fauna underpass	General species	Standard fauna fence
10	Twin Bridges over Seven Hills Road	Brush-tailed Phascogale*, Common Planigale, Green-thighed Frog	Standard, Phascogale and Frog fence
12	Combined drainage and fauna underpass	Brush-tailed Phascogale*, Green-thighed Frog	Standard, Phascogale and Frog fence
13B	Combined drainage and fauna underpass	Brush-tailed Phascogale*, Green-thighed Frog	Standard, Phascogale and Frog fence
14	Combined drainage and fauna underpass	Brush-tailed Phascogale*, Green-thighed Frog	Standard, Phascogale and Frog fence
15	Combined drainage and fauna underpass	Brush-tailed Phascogale*	Standard and Phascogale fence

* = key target species.

2.2 Survey method

Remote cameras

Two automated cameras were installed in each underpass and left operational for 60 consecutive days. At each underpass, one camera was directed along the installed fauna furniture and one just above ground level. This maximised the chance of detecting small, medium and large fauna traveling via the ground or using fauna furniture.

Hair tube and opportunistic searches

Ten hair tubes were deployed at each underpass and left for 15 consecutive nights. The hair tubes were attached to fauna furniture at different heights within the underpasses and placed in habitat adjacent to each underpass. Each hair tube was baited with a mixture of oats and peanut butter. Dog food was smeared near some of the traps to attract a variety of fauna. Samples were sent to Barbara Triggs ('Dead Finish') for analysis, and were identified to species level where possible. Opportunistic searches for scats and tracks were undertaken within each underpass during camera and hair tube deployment and retrieval.

Fauna fences

Monitoring of the fauna fences involved surveying the fence line on foot for 250 m north and south of the underpass and on both sides of the carriageway. Breaches, damage and maintenance issues, such as vegetation growth, were noted and their location recorded.

Road kill

Road kill surveys of the entire F2E section of the highway were undertaken once a week over four weeks during the summer and autumn monitoring events. These surveys involved observations made from a vehicle travelling at approximately 80 km/h. Road kill fauna observed on the road and within three metres of the road verge were recorded by the passenger. Due to the safety issues associated with the operational highway, it was not possible to stop the vehicle to closer inspect or remove road kill. Road kill records were grouped into general fauna groups for analysis.

3. Results

3.1 Fauna use of underpasses

Surveys periods were as follows:

- *Summer 2016/2017*: November 30 2016 – February 1 2017.
- *Autumn 2017*: May 1 2017 - July 6 2017. While hair tube, fauna fence and road kill surveys were undertaken in autumn, the camera traps were deployed for a 60 day period that extended into winter. This was due to a scheduling delay in deployment that will be rectified next monitoring.

Combined results from the different survey methods and both survey periods, to provide an overall indication of the use of the nominated underpasses, are presented in Table 3 and Table 4. Individual survey results for remote cameras, hair tubes and opportunistic surveys are provided in Annex 1. Plates 1 to 5 present a sample of remote camera images.

While specific surveys to determine “*complete passage*” of individuals have not been specified in the EMP, it is considered that animals captured within the underpass on remote cameras are using the underpass to complete successful crossings.

It should be noted that one camera at underpass 10 was stolen during the autumn 2017 surveys. Photos from this camera are therefore not available for this period.

Table 3: Fauna classes recorded at underpasses in 2016/2017 (summer and autumn)

Monitoring Species/Group	6	7	10	12	13B	14	15
Frogs							
Reptiles	✓	✓	✓	✓	✓	✓	✓
Small Ground Dwelling Mammals	✓	✓ ^	✓	✓	✓	✓	✓
Echidna		^			✓	✓	
Possums	✓	✓	✓	✓		✓	
Macropods	✓		✓	✓	✓	✓	✓
Records (#detected/#relevant)	4/6	2/4	5/6	4/6	4/6	5/6	3/6

✓ = presence, ^ = not previously recorded in the vicinity and therefore not considered a relevant fauna group, as per EMP.

Table 4: Targeted species

Underpass	Targeted species (as per Table 3-3 in the EMP)	Targeted fauna recorded	Records (#detected / #nominated)
6	Brush-tailed Phascogale*	No	0/1
7	General species	Two of the four relevant fauna groups and Brush-tailed Phascogale*	2/4
10	Brush-tailed Phascogale*, Common Planigale, Green-thighed Frog	Brush-tailed Phascogale**	1/3
12	Brush-tailed Phascogale*, Green-thighed Frog	No	0/2
13B	Brush-tailed Phascogale*, Green-thighed Frog	No	0/2
14	Brush-tailed Phascogale*, Green-thighed Frog	No	0/2

Underpass	Targeted species (as per Table 3-3 in the EMP)	Targeted fauna recorded	Records (#detected / #nominated)
15	Brush-tailed Phascogale	No	0/1

= deceased individual recorded during other Niche monitoring surveys (Niche 2017a), * = key target species.

3.1.1 Use of underpasses by a range of species

Fauna groups

Representatives of five of the six fauna groups (Table 1) were recorded using at least one underpass during the 2016/2017 monitoring (Table 3), frogs being the only fauna group not detected. The most common native species detected using underpasses included the Lace Monitor (*Varanus varius*), Water Dragon (*Intellagama lesueurii*), Swamp Wallaby (*Wallabia bicolor*), Common Brushtail Possum (*Trichosurus vulpecula*), Bandicoots and Antechinus. Each underpass showed use by a range of the nominated fauna groups, with at least three (maximum five) of the six fauna groups being recorded at any one underpass. While frogs have been previously recorded in the vicinity of all monitored underpasses, and were noted in adjacent habitat during the current monitoring period, they were not recorded using the underpasses. This lack of detection could be attributed to the survey methods and weather conditions at the time of surveys. Hair tubes, remote cameras and limited opportunistic surveys are generally not very effective at detecting small, and often cryptic, amphibian species. Continued monitoring, as per the EMP, will add to the number of fauna records at each underpass. The data pool of fauna detected using underpasses will increase as more information is acquired in the subsequent surveys.

Targeted species

The EMP also identifies targeted species for each underpass (Table 2). Table 4 presents the records for these targeted species for each underpass. Targeted species have only been recorded at two of the seven underpasses: Brush-tailed Phascogale and two of the four relevant fauna groups (reptiles and possums) at underpass 7 and one deceased Brush-tailed Phascogale at underpass 10. Targeted species for the other underpasses include the Brush-tailed Phascogale and the Green-thighed Frog. As mentioned previously, the likelihood of detecting frog species, including the Green-thighed Frog, using current survey methods is low. Continued monitoring, as per the EMP, will add to the number of records at each underpass. The data pool of fauna detected using underpasses will increase as more information is acquired in subsequent surveys.

Use of underpasses by non-native predators

Non-native predators were detected at six of the seven monitored underpasses. These species were not detected at underpass 10 (the only underpass that is a road). Cats were detected at underpass 6, 7, 12 and 15, dogs at underpass 6, 7, 13B and 14, and the fox (*Vulpes vulpes*) at underpass 7, 14 and 15. The highest rate of use by non-native predators was at underpass 7, where 25% of visitations in autumn were by cats and fox on 25% of the days monitored.

3.1.2 Use of underpasses by key target species

The key target species nominated in the EMP, the Brush-tailed Phascogale, was recorded at one underpass (underpass 7) during the underpass survey. Interestingly it was not previously recorded near underpass 7 and therefore was not considered as a target species for this particular underpass.

An incidental record during Brush-tailed Phascogale monitoring surveys undertaken by Niche in May 2017 also noted a deceased male Brush-tailed Phascogale in underpass 10 (Niche 2017a).

3.1.3 Use of underpasses by fauna with low dispersal abilities

Fauna with low dispersal ability was not defined within the EMP. As such fauna with low dispersal ability has been assumed to include animals whose dispersal ability is generally limited by their size, i.e. this would include smaller terrestrial fauna species, which have a reduced ability to disperse compared to larger, more mobile species. Fauna with low dispersal abilities has been interpreted as including individuals from four fauna groups (as per Niche 2017b): frogs, reptiles, small ground dwelling mammals and the echidna. This definition was determined in consultation with RMS.

All underpasses recorded representatives of reptiles and small ground dwelling mammals, while the echidna was recorded using two of the six relevant underpasses for this species. As above, frogs were not recorded using the underpasses.

3.2 Fauna Fences

Fauna fence inspection and road kill results are provided in Annex 2 and Annex 3. 13600 m (51.3%) of the 26520 m of the Frederickton to Eungai section of the highway is fenced with a minimum of standard fauna fencing (data provided by RMS).

3.2.1 Maintenance

A number of maintenance issues were identified during the 2016/2017 monitoring. These are provided in Table 12. Maintenance is required in relation to vegetation encroachments*, gaps underneath the fence caused by environmental factors i.e. water or erosion, platting or netting lifting and damage to the frog fence where it has either been burned or has fallen down. The maintenance issues should be addressed to prevent passage of fauna onto the road.

*At the time of this report the summer 2017/2018 fauna fence surveys had been undertaken. It should be noted that substantial vegetation growth has occurred along the fence lines and vegetation removal is required at the majority of underpasses to ensure the integrity of the fauna fence.

3.2.2 Fence breaches

While no fauna was recorded on the highway side of the fauna fencing, a single record of a digging was made, however it was not possible to conclude definite passage of fauna. Undertaking maintenance to ensure secure fastening of the base netting should prevent these occurrences.

3.2.3 Road kill

Total alignment[^]

Fauna groups

There were a total of 64 and 61 road kill records in summer 2016/2017 and autumn 2017, respectively. Table 5 presents the number of road kill for each identified group and Graph 1 shows the number of road kill recorded for each animal group during the summer and autumn surveys. Figures 2a and b show the distribution of road kill along the alignment. After 'unknown' records, mammals were the most frequently recorded, representing 26.4% of the annual road kill. It is also

considered likely that the majority of 'unknown' records would have represented small to medium sized mammals, as reptiles and birds are more distinct and can be more easily identified.

Distribution of records

Not considering birds, Figure 2, shows a number of areas where road kills appear to be grouped, notably in unfenced areas south of underpass 6 (south of Mill Lane) and south of underpass 10. For non-bird deaths within fenced areas, the majority of records occurred in the vicinity of underpass 10. An analysis of the number of road kill events (excluding birds) that occurred within a fenced area or outside a fenced area of the highway (considering those road kill observations made at the edge of a fenced area to be outside), found that 35 (33.3%) records were within and 70 (66.7%) records were outside fenced areas (Table 5). The number of records for each fauna group was consistently higher in unfenced areas except for introduced mammals (Table 5, Fox, Hare and Rabbit). However these data should be considered with regard to fencing proportion along the highway. Approximately 51.3% is fenced while the remaining 48.7% is unfenced road in (mostly) open areas with limited vegetation. Calculation of a *road kill per metre* rate (excluding birds) found the rate of road kill in unfenced areas (0.0054) to be double the rate in fenced areas (0.0026).

Due to safety issues road kill could not be removed following each survey and therefore may have been recorded multiple times over the four weekly surveys resulting in double-counting and numerous ‘unknown’ records as the condition of the animal deteriorates.

Comparison with previous monitoring

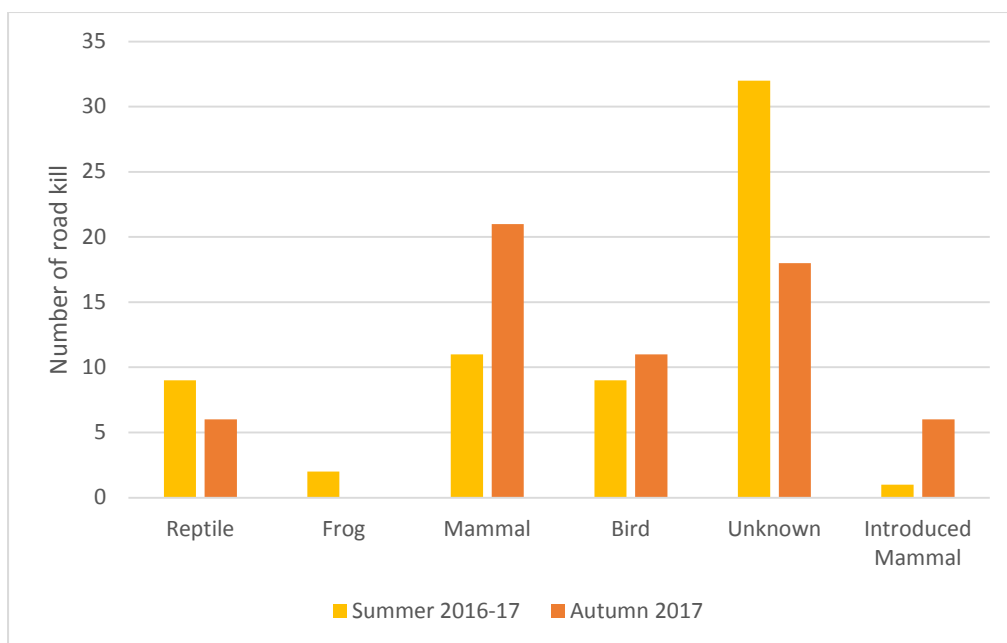
As baseline data is not available for this Project, rates of road kill cannot be defined as low or high in comparison to the pre-existing environment. Instead, road kill records from the road opening survey (Niche 2017c) were used as an indicator of road kill levels in the area at that time. It is important to note that road kill rates are expected to be higher immediately after road opening and that these rates have been used only as a means for comparison, as opposed to as an indicator of ‘usual’ levels.

There were 64 records from four weekly surveys in summer 2016/2017, 61 records from four weekly surveys in autumn 2017, and 95 records from the 21 day road opening survey in May – June 2016, representing a weekly average of 16.0, 15.25 and 31.7 respectively. It appears that the average weekly road kill has reduced from the average recorded immediately after the opening of the road.

[^]At the time of this report a large number of *Limnodynastes peronii* (Striped Marsh Frog) were reported as road kill between 1 – 4 January 2018, south of the Clybucca Rest Area (shown on Figure 2a). This event followed substantial rainfall and occurred in proximity to a large sediment pond, adjacent to wet sclerophyll forest habitat. Frog fencing has not been installed in this area.

Table 5: Grouped road kill records

	Birds	Mammal	Reptile	Amphibian	Unknown	Intro. mammal	TOTAL
AUTUMN							
Number	11	22	6	0	16	6	61
% of autumn RK	18.0	36.0	9.8	0.0	26.2	9.8	
SUMMER							
Number	9	11	9	2	32	1	64
% of summer RK	14.1	17.2	14.1	3.1	50.0	1.6	
ANNUAL							
Number	20	33	15	2	48	7	125
% of fauna group autumn	55.0	66.7	40.0	0.0	33.3	85.7	
% of fauna group in summer	45.0	33.3	60.0	100.0	66.7	14.3	
% of all RK	16.0	26.4	12.0	1.6	38.4	5.6	
#inside fenced area		8	6	2	13	6	35
#outside (+edge) fenced area		25	9	0	35	1	70



Graph 1: Summer and autumn road kill

Fauna fence (within 500 m of underpasses)

As per the EMP, success of the fauna fences is to be determined by *“the absence of specific road struck fauna including Echidna, Koala, Possums (Common Brushtail, Common Ringtail) and macropods (Swamp Wallaby, Red-necked Wallaby, Eastern Grey Kangaroo) on the highway carriageway in the immediate vicinity (i.e. <500 m) of the fauna underpasses. Where phascogale fencing has been installed, the degree of success will be based on the absence of road killed Brush-tailed Phascogale and other scansorial fauna (i.e. Antechinus). Similarly, for frog fencing, its success will be based on the absence of Green-thighed Frog fence breaches/road strike.”*

Road kill records within 500 m of the underpasses are provided in Table 6 and presented in Figures 3a and b.

- Standard floppy top fencing: There were no road kill records of Echidnas or Koalas within 500 m of the underpasses. Four macropods and one possum were recorded as road kill within 500 m of underpasses. Macropods were recorded in the vicinity of underpass 6 and 10, while the possum was recorded in the vicinity of underpass 14. Macropods were detected using both of these underpasses and the possum was detected using underpass 14.
- Phascogale fencing: No Brush-tailed Phascogales were recorded as road kill during the current surveys. The cause of death of the individual found at underpass 10 was unknown.
- Frog fencing: Two frogs were recorded as road kill during the summer 2016/2017 surveys, however these were not identified to species level and occurred outside the 500 m range of the underpasses.

Table 6: Road kill recorded within approx. 500m of an underpass

Underpass	Date	Distance approx. (m)	Side (E/W)	Species
6	25/05/17	165	E	Bird
6	17/05/17	162	E	Unknown
6	11/05/17	223	E	Bird
6	19/12/16	288	E	Swamp Wallaby
6	12/12/16	343	W	Unknown
6	12/12/16	366	E	Swamp Wallaby
6	28/11/16	350	E	Unknown
6	28/11/16	19	W	Black and white bird
7	17/05/17	277	E	Magpie
7	11/05/17	35	E	Snake
7	02/05/17	315	E	Snake
7	02/05/17	382	E	Unknown
7	19/12/16	316	E	Turtle
7	12/12/16	312	E	Turtle
7	28/11/16	350	E	Unknown
10	17/05/17	270	E	Red-necked Wallaby
10	25/05/17	246	E	Unknown
10	12/12/16	146	E	Snake?
10	12/12/16	412	E	Turtle
10	28/11/16	255	W	Eastern Grey Kangaroo
12	17/05/17	218	W	Unknown
12	11/05/17	66	E	Rodent
12	11/05/17	221	W	Kookaburra
12	02/05/17	20	E	Rabbit
12	02/05/17	292	W	Kookaburra
12	28/11/16	367	E	Unknown
14	17/05/17	369	W	Possum
14	17/05/17	466	W	Unknown
14	11/05/17	491	W	Unknown
14	11/05/17	323	E	Unknown
14	02/05/17	410	W	Unknown mammal

4. Discussion

4.1 Performance measures

A summary of the summer 2016/2017 and autumn 2017 survey results in relation to the performance indicators is provided in Table 7.

Table 7: Performance indicators of success.

Performance indicators of success	Discussion
Use of fauna underpasses by a range of the nominated indicator species.	This performance indicator of success has been met. Each underpass showed use by a range of the nominated fauna groups, with at least three (maximum five) of the six fauna groups being recorded at each underpass. Frogs have not been recorded using any underpass to date. Use of the underpass is assumed to imply complete passage.
Use of the fauna underpass by key target species.	This performance indicator of success has been met at underpass 7 only. The majority of key target species have not yet been recorded for each underpass. Continued monitoring, as per the EMP, will add to the number of records at each underpass. The data pool of fauna detected using underpasses will increase as more information is acquired through subsequent monitoring.
Use by fauna with low dispersal ability. Four fauna classes fall into this category, including frogs, reptiles, small ground dwelling mammals and the echidna.	This performance indicator of success has been met by three of the four low dispersal fauna categories. Frogs have not been detected using any underpass, however survey methods do not favour their detection. The echidna has been recorded using two of the underpasses. Reptiles and small ground dwelling mammals have been recorded at all underpasses.
Low rate of fauna road strike.	This performance indicator of success has been met. A reduction in road kill has been observed since road opening. However it is important to note that road opening surveys do not represent baseline values as elevated levels of road kill are expected on road opening. Baseline data is not available for comparison. Subsequent surveys will provide information required to better understand road kill rates in the area. The majority (66.7%) of road kill records occurred outside or at the edge of fenced areas.
No breaches in the fauna fence.	This performance indicator of success has been met. No fauna was recorded on the highway side of the fauna fencing, a single record of a digging was made, however it was not possible to conclude definite passage of fauna.
Additional determinants of success specified the EMP	
Absence of specific road kill fauna within 500 m of underpasses.	This performance indicator of success has been met for two of the three fauna fence types. Four macropod and one possum road kill record occurred within 500 m of underpass 6, 10 and 14.

5. Recommendations

5.1 Contingency measures

The EMP lists potential problems and contingency measures for various components of the monitoring program. Those that are related to the underpass monitoring program are listed and discussed in Table 8.

Table 8: Contingency measures

Potential Problem	Contingency Measure proposed in EMP	Discussion of proposed measure
Low usage rates of native fauna	<ul style="list-style-type: none"> Review/modify habitat structure adjoining the underpass 	<p>Each underpass showed use by a range of the nominated fauna groups, with at least three (maximum five) of the six fauna groups being recorded at each underpass.</p> <p>Frogs have not been recorded using any underpass to date.</p> <p>This contingency measure is not considered relevant.</p>
A range of indicator species groups not using the underpass structure	<ul style="list-style-type: none"> Review/modify underpass fauna furniture or ground cover attributes adjoining the underpass. Consider additional monitoring Consult with EPA 	<p>Not all fauna groups and target species have been detected at all underpasses during the current monitoring event. Frogs are notably absent from all underpasses.</p> <p>These contingency measures are considered relevant for the use of underpasses by frogs.</p>
High visitation/usage rates by exotic predators	<ul style="list-style-type: none"> Review/modify design. Seek advice from LHPA concerning control methods. 	<p>While “High visitation/usage rates” was not defined in the EMP, high usage rates has been considered as where visitation by exotic predators equates to greater than 25% of visitations to the underpass or as visitations by exotic predators on more than 25% of the days monitored. This is based on previous underpass monitoring outcomes (Sandpiper Ecological 2015, Sandpiper Ecological 2017) and in consultation with North Coast Local Land Services (Biosecurity Manager). Exotic predators have been observed using the underpasses, notably underpass 7 at a higher frequency. In autumn 25% of visitations were by exotic predators on at least 15 separate days (25% of monitoring days). The rate of use by these species will continue to be monitored.</p> <p>This contingency measure is considered relevant for underpass 7.</p>
Unacceptable rates of road strike in the vicinity of the underpasses (<250m) [sic]	<ul style="list-style-type: none"> Review/modify fauna exclusion fencing design, location or extent depending on road struck species. 	<p>Road kill within 500 m of underpasses was analysed, as per EMP text. Overall road kill rates and road kill within 500 m of underpasses were not considered to be at unacceptable levels. Subsequent surveys will provide information required to better understand road kill rates in the area.</p> <p>This contingency measure is not considered relevant.</p>
Road strike of species which the fence is designed to exclude	<ul style="list-style-type: none"> Inspect fence for breaches and inform maintenance as necessary. Review fence design. 	<p>Macropods and a possum were recorded as road kill within 500 m of underpasses.</p> <p>These contingency measures are considered relevant for macropods and possums.</p>

5.2 Recommendations

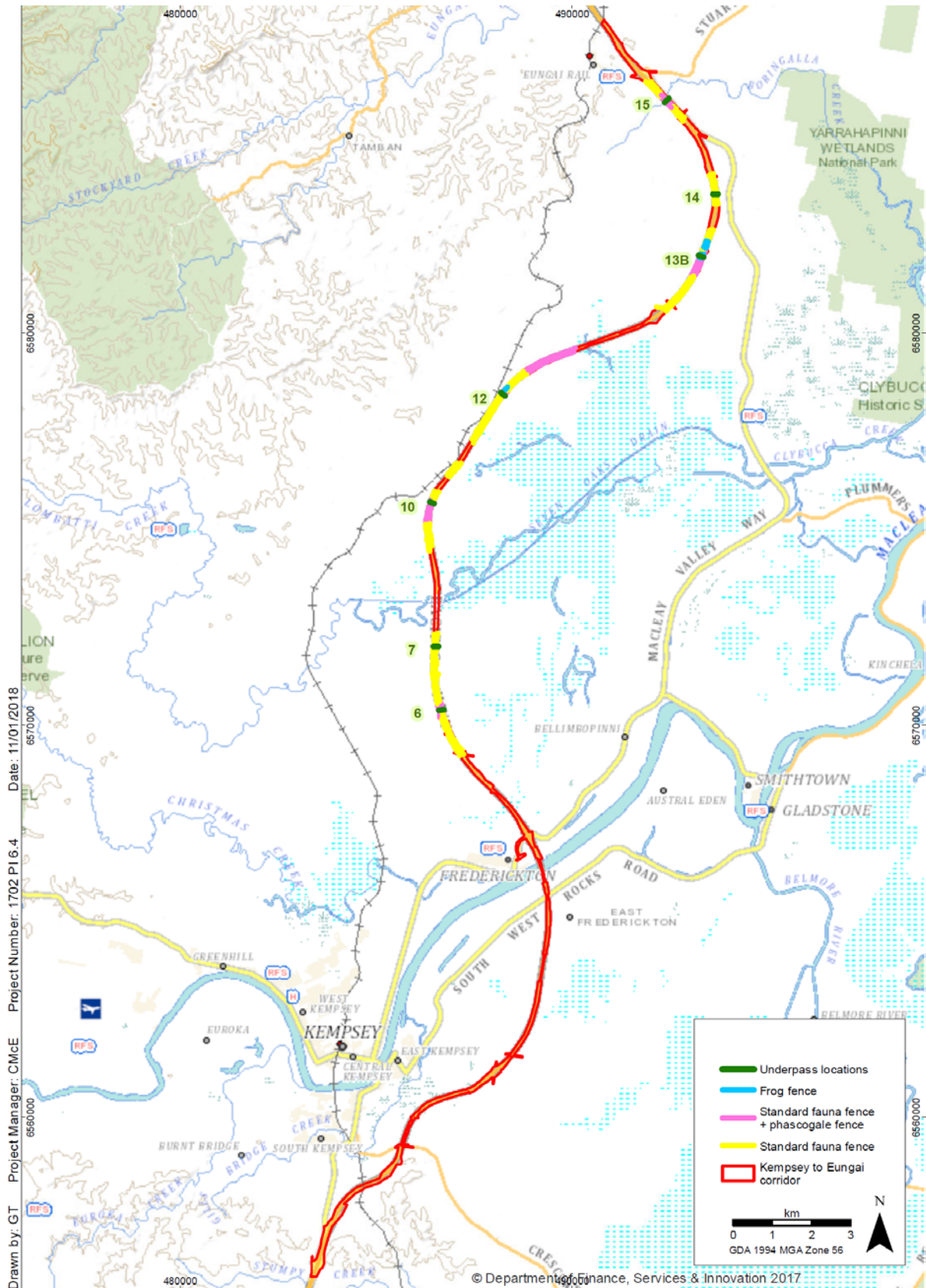
The recommendations provided in Table 9 aim to address proposed contingency measures and to meet performance criteria.

Table 9: Recommendations

Problem identified in 2016/2017 monitoring	Discussion/Recommendations
Absence of use of the fauna underpasses by key target species	<ul style="list-style-type: none"> Continue monitoring as per the EMP as this will add to the number of records at each underpass. The data pool of fauna detected using underpasses will increase as more information is acquired in subsequent surveys and allow for a better understanding of fauna presence and use of underpasses at each site.
Absence of some fauna groups from all underpasses.	<ul style="list-style-type: none"> Consider increasing remote camera monitoring periods to increase detection opportunity. Failure to detect specific faunal groups using underpasses at the completion of the 2017/2018 monitoring should result in a review and modification of underpass fauna furniture or ground cover attributes adjoining the underpass to cater to absent groups.
Lack of evidence of use by frog species.	<ul style="list-style-type: none"> The likelihood of detecting the Green-thighed Frog and other amphibians using current survey methods is low. Consider undertaking targeted frog surveys/dip netting within underpasses 12, 13B and 14 for tadpoles during/following suitable weather conditions (underpass 10 does not contain a wet area).
Road kill records of specific fauna within 500 m of underpasses.	<ul style="list-style-type: none"> Continue monitoring as per the EMP. Continued road kill in areas where fauna fences are in place should result in inspection of the complete length of the fence with maintenance undertaken where necessary. If strikes continue to occur at the limits of fencing, notably north of underpass 7, consideration should be given to the extent of the fencing, taking the extent of adjacent habitat into account.
High visitation/usage rates by exotic predators	<ul style="list-style-type: none"> Consider consulting with Local Land Services concerning control methods for foxes and cats in the area.
Striped Marsh Frog road kill event	<ul style="list-style-type: none"> As adjacent wet sclerophyll forest, sediment pond and nearby habitat is likely to support a number of frog species, it is possible that other species were among the large number of individuals recorded as road kill during this event. Consideration should be given to deploying a suitably qualified ecologist during any future large road kill event such as this, to identify species in order to determine the presence of threatened species and therefore the need for additional frog fencing in the area.

6. References

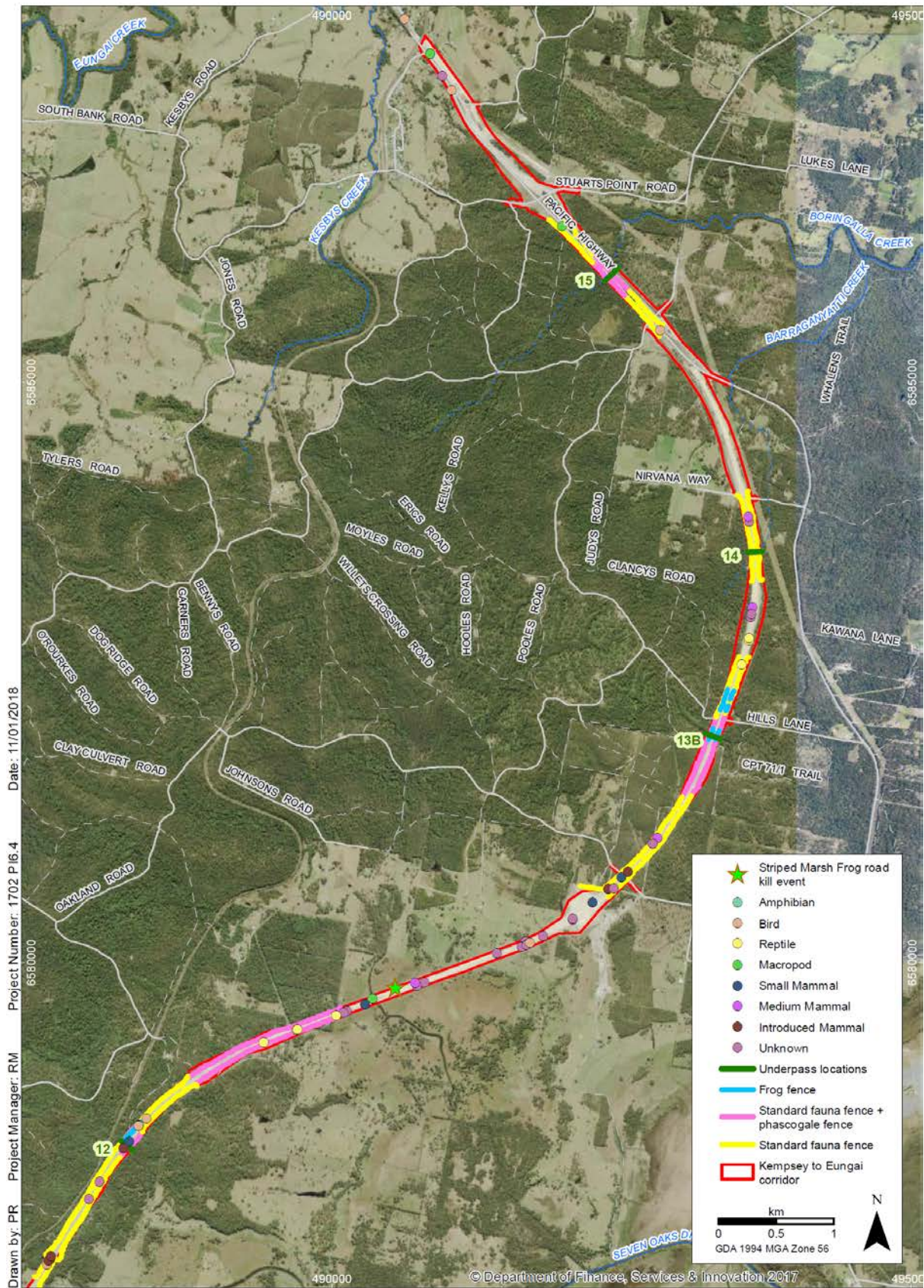
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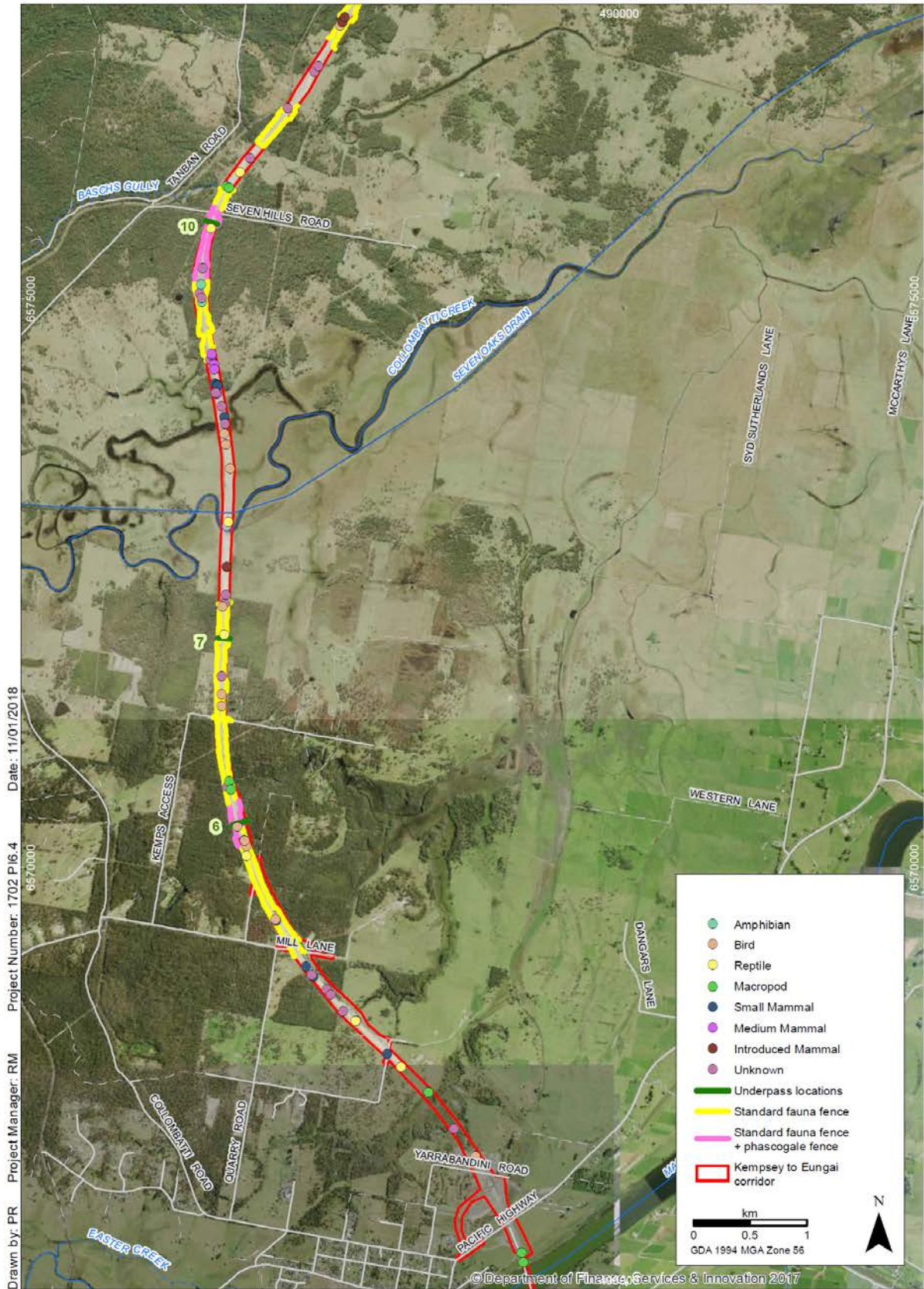
Frederickton to Eungai - Underpass locations
Oxley Highway to Kempsey - PI 6.4 Fauna Underpasses

FIGURE 1

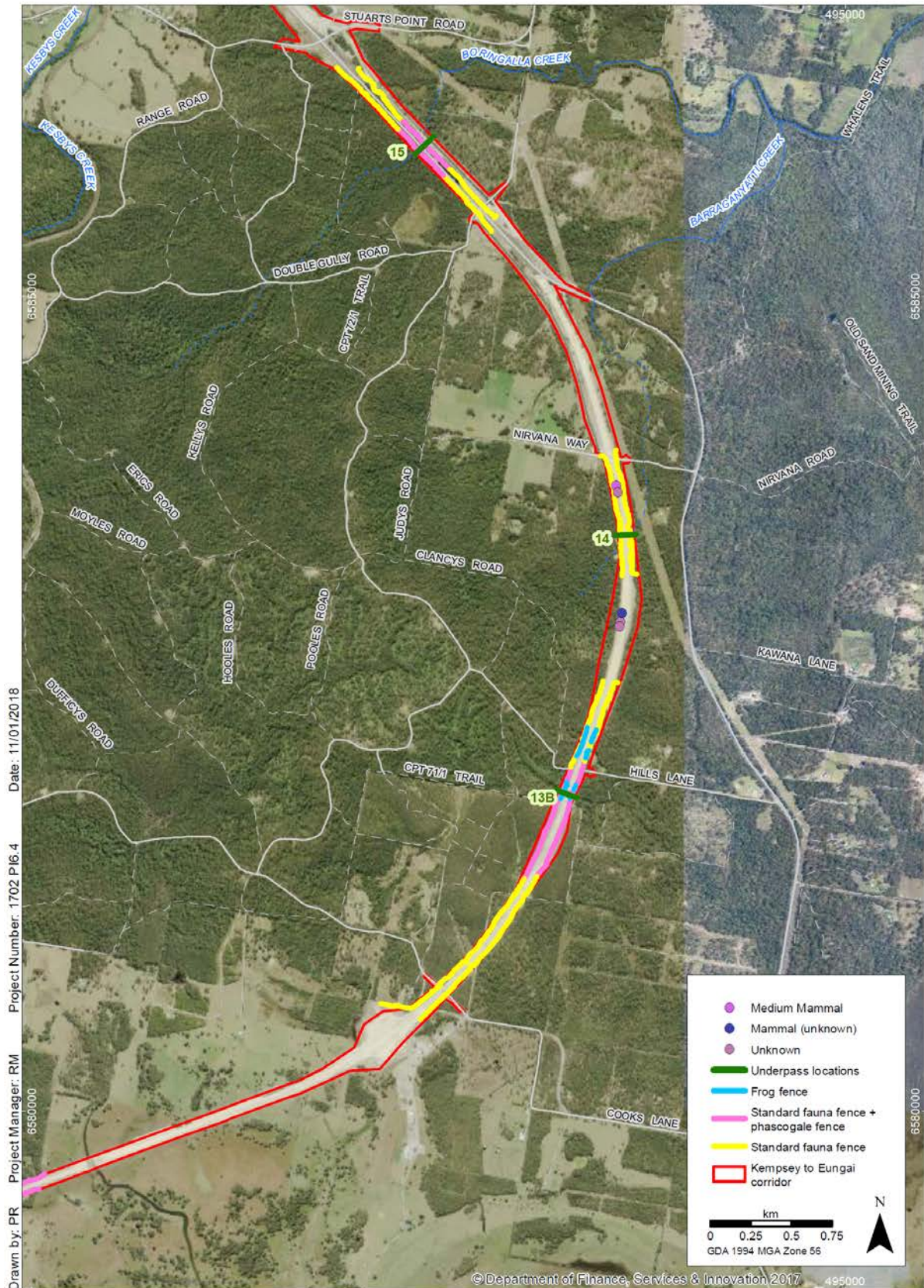
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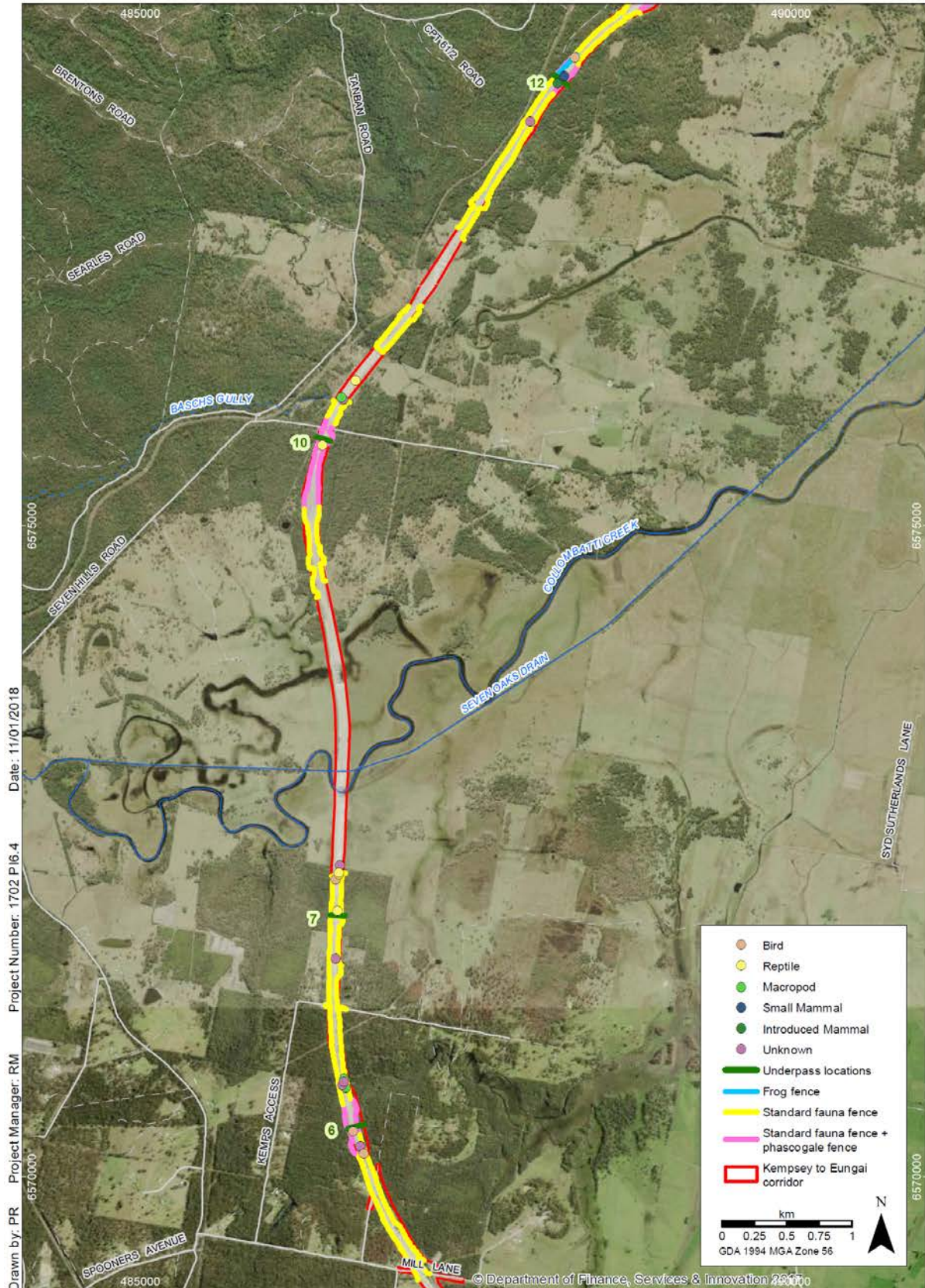
Road kill monitoring 2016/2017 Pacific Highway Upgrade – Frederickton to Eungai
Oxley Highway to Kempsey - PI 6.4 Fauna Underpasses



Road kill monitoring 2016/2017 Pacific Highway Upgrade – Frederickton to Eungai
Oxley Highway to Kempsey - PI 6.4 Fauna Underpasses



Road kill monitoring 2016/2017 within 500 m of underpass
Oxley Highway to Kempsey - PI 6.4 Fauna Underpasses



Road kill monitoring 2016/2017 within 500 m of underpass
Oxley Highway to Kempsey - PI 6.4 Fauna Underpasses

Imagery: (c) LPI NSW 2014 **FIGURE 3b**

Path: T:\spatial\projects\1700\1702_OH2K_Ecology\Maps\PI_6_EcolMonit_F2E\PI_6_Underpass\2017\1214_FaunaFence\1702_PI64_Fig3b_FaunaFence_2017\1214.mxd



Plate 1: Red Fox (*Vulpes vulpes*) at underpass 7, autumn 2017



Plate 2: Lace Monitor (*Varanus varius*) at underpass 7, summer 2016/2017



ScoutGuard

12.04.2016 23:36:51

Plate 3: Mountain Brushtail Possum (*Trichosurus cunninghami*) at underpass 12, summer 2016/2017.



ScoutGuard

02.08.2017 23:15:49

Plate 4: Echidna (*Tachyglossus aculeatus*) at underpass 13B, summer 2016/2017



Plate 5: Water Rat (*Hydromys chrysogaster*) at underpass 14, autumn 2017

Annex 1 – Underpasses

Table 10: Species detected via remote cameras - summer 2016/2017 and autumn 2017.

Species	6		7		10		12		13B		14		15	
	summer	autumn	summer	autumn	summer	autumn	summer	autumn	summer	autumn	summer	autumn	summer	autumn
<i>Rattus sp.</i>	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓
Water Rat (<i>Hydromys chrysogaster</i>)		✓										✓		
Small mammal/possible Antechinus	✓			✓						✓	✓	✓		✓
Brush-tailed Phascogale (<i>Phascogale tapoatafa</i>)			✓	✓										
Swamp Wallaby (<i>Wallabia bicolor</i>)					✓	✓		✓	✓				✓	✓
Red-necked Wallaby (<i>Macropus rufogriseus</i>)					✓				✓					
Eastern Grey Kangaroo (<i>Macopus giganteus</i>)					✓				✓					
Common Brushtail Possum (<i>Trichosurus vulpecula</i>)			✓	✓				✓					✓	
Mountain Brushtail Possum (<i>Trichosurus caninus</i>)							✓							
Northern Brown Bandicoot (<i>Isodon macrourus</i>)		✓			✓								✓	
Long-nosed Bandicoot (<i>Perameles nasuta</i>)			✓											
Echidna (<i>Tachyglossus aculeatus</i>)									✓			✓		
Bat										✓				
Water Dragon (<i>Intellagama lesueurii</i>)	✓							✓	✓		✓		✓	✓
Lace Monitor (<i>Varanus varius</i>)	✓		✓		✓		✓	✓	✓		✓		✓	
Pacific Black Duck (<i>Anas superciliosa</i>)								✓				✓	✓	
White-faced Heron (<i>Egretta novaehollandiae</i>)												✓		
Bird		✓							✓					
Cat (<i>Felis catus</i>)	✓			✓			✓							
Dog		✓	✓						✓	✓				
Rabbit (<i>Oryctolagus cuniculus</i>)		✓		✓										
Fox (<i>Vulpes vulpes</i>)				✓								✓	✓	✓

Table 11: Hair tube results - summer 2016/2017 and autumn 2017

Species	6		7		10		12		13B		14		15	
	S	A	S	A	S	A	S	A	S	A	S	A	S	A
<i>Rattus</i> spp.		√				√	√	√	√	√		√		√
<i>Rattus Rattus</i>		√				√		√						
House Mouse (<i>Mus musculus</i>)				√				√						
Rodent		√		√		√	√			√		√		√
Swamp Wallaby											√			
Brush-tail Possum (<i>Trichosurus</i> sp.)		√						√			√			
Cat														√

Table 12: Scats and Tracks - summer 2016/2017 and autumn 2017

Species	6		7		10		12		13B		14		15	
	S	A	S	A	S	A	S	A	S	A	S	A	S	A
Frog											√ I			
Turtle	√ I													
Lace Monitor							√ I							
Water Dragon											√ I		√ I	
Reptile								√ C						√ C
Swamp Wallaby	√ C													
Eastern Grey Kangaroo	√ C													
Wallaby						√ T								
Macropod				√ T					√ C	√ C	√ C	√ C	√ C	
Rodent				√ C				√ C		√ C				√ C
Dog									√ I		√ T	√ T		
Cat				√ T										

S = summer, A = autumn, I = sight, C = scat, T = track

Annex 2 – Fence Inspections

Table 13: 250 m fauna fence inspections-summer 2016/2017 and autumn 2017 surveys

Date	Breach/maintenance /fence ended	Site	Comments
30/11/2016	Erosion	6	Erosion under fence creating gap
30/11/2016	Vegetation	6	Turtle blocked by fence from entering road, small acacias that may become a problem.
30/11/2016	Vegetation	6	Melaleuca growing too close to fence
30/11/2016	Erosion	7	Erosion under fence creating gap
30/11/2016	Lifted netting	7	Gap
30/11/2016	Fauna gate mesh at bottom loose	10	Possible passage
30/11/2016	SE Fence ends 207m	14	
30/11/2016	SW fence end 180m	14	
30/11/2016	Fauna plate ends 207m	15	
30/11/2016	Fauna fence plating finishes 100m	13B	
30/11/2016	Fauna fence plating finishes	13B	
30/11/2016	Fauna plating ends	13B	
30/11/2016	NE Fence gate missing hinge and lock	13B	
01/05/2017	Gap under fence	6	Animal has dug under fence.
01/05/2017	Gap under fence	6	Caused by erosion.
01/05/2017	Vegetation overgrown	7	Possible passage
01/05/2017	Digging	7	No evidence of successful passage?
01/05/2017	Vegetation overgrown	7	Possible passage
01/05/2017	Gap under fence	12	Erosion/ Runoff causing holes under fence.
01/05/2017	Frog fence down	14	Possible frog passage
01/05/2017	Fence lifting	14	Drainage line - debris lifting wire
01/05/2017	Gap	14	Gap in frog fence.
01/05/2017	Missing frog fence	14	Possibly burnt?
02/05/2017	Gap	15	Gap in lower mesh and main fence
02/05/2017	Gap	15	Gap in lower mesh and main fence
02/05/2017	Gap	13	In gutter
02/05/2017	Gap	13	In gutter
02/05/2017	Detached Frog Fence	13	Possible frog passage

Annex 3 – Road Kill

Table 14: Road kill data-summer 2016/2017 and autumn 2017

Date	Northing	Easting	Species/vertebrate group	Animal Group
28/11/2016	6567695	488542	Unknown	Unknown
28/11/2016	6568242	488074	Unknown	Reptile
28/11/2016	6568730	487564	Blood spot	Unknown
28/11/2016	6570352	486632	Black and white bird	Bird
28/11/2016	6574459	486395	Blood spot	Unknown
28/11/2016	6575043	486299	Blood spot	Unknown
28/11/2016	6575991	486541	Eastern Grey Kangaroo	Mammal
28/11/2016	6576672	487079	Unknown	Unknown
28/11/2016	6580178	491671	Blood spot	Unknown
28/11/2016	6587517	491034	Bird	Bird
28/11/2016	6588130	490626	Bird	Bird
28/11/2016	6587828	490849	Unknown	Unknown
28/11/2016	6587828	490849	Eastern Grey Kangaroo	Mammal
28/11/2016	6580227	491821	Unknown	Unknown
28/11/2016	6580160	491683	Blood spot	Unknown
28/11/2016	6579828	490799	Blood spot	Unknown
28/11/2016	6579803	490732	Blood spot	Unknown
28/11/2016	6579583	490133	Blood spot	Unknown
28/11/2016	6579571	490099	Unknown	Unknown
28/11/2016	6579548	490036	Turtle	Reptile
28/11/2016	6578110	487997	Unknown	Unknown
28/11/2016	6577963	487906	Blood spot	Unknown
28/11/2016	6576993	487309	Blood spot	Unknown
28/11/2016	6576232	486743	Blood spot	Unknown
28/11/2016	6575271	486324	Blood spot	Unknown
28/11/2016	6575121	486316	Small Frog	Amphibian
28/11/2016	6574969	486322	Small Frog	Amphibian
28/11/2016	6574379	486428	Blood spot	Unknown
28/11/2016	6574222	486459	Blood spot	Unknown
28/11/2016	6574055	486492	Blood spot	Unknown
28/11/2016	6572644	486538	Hare	Mammal
28/11/2016	6571678	486497	Blood spot	Unknown
28/11/2016	6571521	486498	Noisy Miner	Bird
28/11/2016	6571416	486492	Wood duck	Bird
28/11/2016	6570737	486561	Unknown	Unknown
28/11/2016	6568923	487419	Blood spot	Unknown
28/11/2016	6568641	487678	Blood spot	Unknown
05/12/2016	6579688	490351	Red-necked Wallaby	Mammal
05/12/2016	6579823	490720	Medium mammal - unknown	Mammal

Date	Northing	Easting	Species/vertebrate group	Animal Group
05/12/2016	6585447	492828	Unknown	Bird
05/12/2016	6587638	490957	Blood spot	Unknown
05/12/2016	6580136	491635	Blood spot	Unknown
05/12/2016	6575006	486320	Unknown	Unknown
05/12/2016	6573036	486555	Turtle	Reptile
05/12/2016	6568881	487452	Unknown	Unknown
05/12/2016	6568641	487676	Turtle	Reptile
12/12/2016	6570100	486716	Live turtle	Reptile
12/12/2016	6570706	486548	Unknown	Unknown
12/12/2016	6577400	487539	Kookaburra?	Bird
12/12/2016	6576115	486653	Turtle	Reptile
12/12/2016	6575618	486398	Snake? -Blood spot	Reptile
12/12/2016	6572339	486528	Turtle	Reptile
12/12/2016	6570753	486561	Swamp Wallaby	Mammal
12/12/2016	6567454	488730	Unknown	Bird
12/12/2016	6566609	489130	Red-necked Wallaby	Mammal
19/12/2016	6566529	489148	Red-headed Flying Fox	Mammal
19/12/2016	6580080	491424	Blood spot	Unknown
19/12/2016	6586346	491983	Red-necked Wallaby	Mammal
19/12/2016	6579421	489693	Possible Tawny Frogmouth	Bird
19/12/2016	6577042	487345	Blood spot	Unknown
19/12/2016	6572324	486527	Turtle	Reptile
19/12/2016	6570682	486574	Swamp Wallaby	Mammal
19/12/2016	6568017	488312	Swamp Wallaby	Mammal
19/12/2016	6566602	489134	Red-necked Wallaby	Mammal
02/05/2017	6569123	487236	Unknown	Mammal/Bird
02/05/2017	6573809	486518	Magpie	Bird
02/05/2017	6574246	486434	Unknown	Small Mammal
02/05/2017	6578660	488401	Kookaburra	Bird
02/05/2017	6580523	492248	Unknown	Small Mammal
02/05/2017	6580631	492384	Fox	Mammal
02/05/2017	6581073	492809	Unknown	Medium Mammal
02/05/2017	6583056	493626	Unknown	Medium Mammal
02/05/2017	6582571	493536	Snake	Reptile
02/05/2017	6578400	488202	Rabbit	Mammal
02/05/2017	6574420	486426	Echidna	Mammal
02/05/2017	6574240	486458	Rat	Rodent
02/05/2017	6573503	486564	Magpie	Bird
02/05/2017	6572323	486525	Unknown	Unknown
11/05/2017	6582777	493597	Snake	Reptile
11/05/2017	6580369	492079	Unknown	Unknown
11/05/2017	6580154	491682	Unknown	Unknown
11/05/2017	6579310	489409	Snake	Reptile

Date	Northing	Easting	Species/vertebrate group	Animal Group
11/05/2017	6578461	488255	Rodent	Mammal
11/05/2017	6574504	486408	Echidna	Mammal
11/05/2017	6574237	486460	Unknown	Unknown
11/05/2017	6573957	486515	Unknown	Mammal
11/05/2017	6572396	486531	Unknown	Unknown
11/05/2017	6572046	486514	Snake	Reptile
11/05/2017	6570179	486712	Bird	Bird
11/05/2017	6568353	487953	Unknown	Mammal
11/05/2017	6569034	487300	Unknown	Mammal
11/05/2017	6569535	486972	Unknown	Mammal
11/05/2017	6573718	486529	Magpie	Bird
11/05/2017	6574165	486448	Unknown	Small Mammal
11/05/2017	6577451	487567	Fox	Mammal
11/05/2017	6578598	488341	Kookaburra	Bird
11/05/2017	6580731	492494	Unknown	Small Mammal
11/05/2017	6581022	492765	Unknown	Unknown
11/05/2017	6582979	493612	Unknown	Unknown
11/05/2017	6583801	493599	Unknown	Unknown
17/05/2017	6569050	487289	Unknown	Unknown
17/05/2017	6569542	486969	Bird	Bird
17/05/2017	6572288	486500	Magpie	Bird
17/05/2017	6574165	486448	Bandicoot	Mammal
17/05/2017	6577433	487554	Fox	Mammal
17/05/2017	6578592	488334	Kookaburra	Bird
17/05/2017	6580787	492555	Fox	Mammal
17/05/2017	6583003	493617	Unknown	Unknown
17/05/2017	6583841	493590	Possum	Mammal
17/05/2017	6580377	492081	Unknown	Unknown
17/05/2017	6574512	486404	Echidna	Mammal
17/05/2017	6574233	486459	Unknown	Mammal
17/05/2017	6573896	486524	Unknown	Unknown
17/05/2017	6570235	486693	Unknown	Unknown
25/05/2017	6574167	486447	Unknown	Unknown
25/05/2017	6577473	487580	Fox	Mammal
25/05/2017	6581025	492768	Unknown	Unknown
25/05/2017	6582794	493602	Snake	Reptile
25/05/2017	6580641	492432	Unknown	Unknown
25/05/2017	6580169	491708	Bird	Bird
25/05/2017	6579637	490287	Unknown	Mammal
25/05/2017	6579424	489703	Snake	Reptile
25/05/2017	6575973	486558	Red-necked Wallaby	Mammal
25/05/2017	6574383	486431	Echidna	Mammal
25/05/2017	6570232	486696	Bird	Bird

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Appendix G Glossy Black Cockatoo



Glossy Black Cockatoo Monitoring 2017

Frederickton to Eungai Pacific Highway Upgrade

Prepared for Roads and Maritime Services

December 2017

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Cover photograph: Glossy Black Cockatoos from unrelated project

Executive summary

Context

This monitoring report documents the third and final round of monitoring conducted at four sites (Kemps Access, Ainsworth (Seven Hills Road), Tamban and Barraganyatti) in autumn 2017 as required by the Frederickton to Eungai (F2E) Ecological Monitoring Program (EMP, RMS 2016).

Aims

The aim of this report is to summarise the methods and results of the Glossy Black Cockatoo (*Calyptorhynchus lathami*) autumn 2017 monitoring, provide an overall discussion of all monitoring events and to determine if performance measures have been met, as per the EMP (RMS 2016).

Methods

Surveys were undertaken at four monitoring sites in autumn 2017. Five quadrats were surveyed within each of the four monitoring sites and data on stem size class, cone presence and any incidental findings, such as chewed cones or Glossy Black Cockatoo presence was recorded. A traverse was undertaken at each site whereby the first 50 cone bearing *Allocasuarina* stems encountered were assessed for foraging activity (presence of chewed cones). Where chewed cones were encountered, the number of cones and their age was estimated using the guides provided in the EMP.

Key results

No significant decline in average stem counts for each age class was detected for Kemps Access, Ainsworth and Barraganyatti. This test could not be performed for the Tamban site as baseline surveys were not undertaken at this site. However a comparison between 2014 and 2017 monitoring events was undertaken and no significant decline was detected.

There was a significant variation in the number of stems bearing cones over the years for all sites except Barraganyatti, however there was no directional trend. A declining trend in cone density is not evident at this time.

Significant variations in foraging activity over the years were observed at Kemps Access and Ainsworth, however, there was no directional trend. A declining trend in foraging activity is not evident at this time. Foraging activity has been recorded at all sites within the quadrats during at least one monitoring event since baseline surveys.

Conclusions

The Glossy Black Cockatoo monitoring program has found no directional declining trends in *Allocasuarina* regeneration, foraging resources or foraging activity at the four monitored sites. Variation in these factors over the years are considered to be due to natural fluctuations in the environment and Glossy Black Cockatoo behaviour. However the absence of control sites for comparison prevents a definitive statement regarding the role of Project activities in the overall availability of foraging resources and level of foraging activity at the sites.

Management implications

There are no recommendations for continued monitoring of these sites as performance measures, as defined in the EMP, have been met. However, if continued monitoring was considered for these sites it would be necessary to establish control sites.

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1. Introduction

1.1 Context

As part of the Frederickton to Eungai (F2E) Pacific Highway Upgrade Project (the Project), Roads and Maritime Services (Roads and Maritime) have implemented an Ecological Monitoring Program (EMP) in accordance with the Minister for Planning's Condition of Approval (MCoA) No. 3.1. This Ecological Monitoring Program (RMS 2016) (hereafter referred to as EMP) combines the approval conditions provided within the Ministers Conditions of Approval (MCoA) and Statement of Commitments (SoC), and defines the mitigation and offsetting requirements for threatened species and ecological communities impacted by the Project.

The Glossy Black Cockatoo (*Calyptorhynchus lathami*) was one threatened species identified as requiring mitigation and monitoring through the course of the Projects' construction and operational period.

1.1.1 Legal status

The Glossy Black Cockatoo is listed as vulnerable under the NSW *Biodiversity Conservation Act 2016* (BC Act) (previously listed under the repealed NSW *Threatened Species Conservation Act 1995* (TSC Act)).

Monitoring of the species is required under the Project's approval.

1.1.2 Monitoring framework

The EMP states the following regarding monitoring:

"In addition to the baseline surveys, three subsequent monitoring events will then be undertaken, commencing in autumn/early winter of 2014 and every 12 – 24 months thereafter with at least one monitoring event undertaken during the operational phase of the project."

To date, these monitoring events have been reported as follows:

- July 2014: Niche 2015
- May 2016: Niche 2017a
- May 2017: current report

This report therefore represents the final monitoring event required by the EMP for the Glossy Black Cockatoo.

1.1.3 Baseline data

The EMP provides the following background data:

"Although there is baseline data relating to the general presence of Glossy Black Cockatoo either through feeding evidence or direct observations of birds, there is no data on exactly how they use the existing Allocasuarina resource and what the future implications of habitat loss may have on the local population."

To overcome this, a baseline survey was conducted in 2013 by Lewis Ecological (Lewis 2014). The following Glossy Black Cockatoo observations were made:

- Kemps Access: three birds (pair with a sub-adult) observed within the monitoring quadrats.
- Ainsworth (Seven Hills Road): five birds flying through the canopy.
- Yerbury: no birds recorded during the survey although one to three birds were observed further to the north within the clearing footprint.

- Barraganyatti: no birds were observed during the survey although two to five birds were observed in this area during the previous two years.

As specified in the EMP, the Yerbury site was not subject to further monitoring due to substantial clearing of *Allocasuarina* stands. A new site, Tamban (ch 2700), specified in the EMP has been monitored, for which a baseline survey was not undertaken.

1.1.4 Purpose of this report

The aim of this report is to provide a summary of the results of the third and final monitoring event for this species and provide an overall summary and comparison of the three monitoring events (autumn 2014, 2016 and 2017) in order to determine if performance measures have been met, as per the EMP.

1.2 Performance measures

The EMP specifies the following performance indicators for the Glossy Black Cockatoo:

Performance indicators of success at each site (i.e. sites used in the baseline survey) will include:

- *Glossy Black Cockatoo using *Allocasuarina* resources to a similar extent (i.e. $p > 0.05$) as the baseline survey*
- *Continued survival of *Allocasuarina**
- *Regeneration/recruitment of *Allocasuarina*.*

Performance indicators of failure will include:

- *Significantly (ANOVA $P < 0.05$) lower levels of *Allocasuarina* use than the baseline survey*
- *No regeneration of *Allocasuarina*.*

1.3 Monitoring timing

Monitoring is to occur in autumn/early winter 2014 and then every 12-24 months thereafter during autumn, as this time coincides with the onset of breeding for the Glossy Black Cockatoo (Pizzey and Knight 2003).

1.4 Reporting

Annual reporting of monitoring results will outline:

- A description of the monitoring methodology employed.
- Results of the monitoring surveys.
- A discussion of the results, including how the results compare against key performance criteria.
- The need for any corrective actions/contingency measures and any general recommendations.

All reports prepared under the EMP will be submitted to the Director General of the NSW Department of Planning and Environment and the NSW Environment Protection Authority (EPA).

1.5 Limitations

The following limitations to the monitoring procedure were encountered:

- Due to the absence of baseline data for the Tamban site, comparisons could not be made and statistical analyses could not be undertaken for this site using baseline data. Instead, comparisons were made with the 2014 data to provide an indication of change. However any detected changes cannot be attributed to Project activities, as these data do not form part of the baseline survey.
- The methods employed for the determination of foraging activity (50 first cone-bearing trees encountered during a random/fixed traverse) preclude these data from statistical analyses that

would identify a real change in foraging activity as each traverse sampled a different subset of 50 trees. Any detected change would reflect a difference in foraging activity between areas and not between years.

- As all sites surveyed were impact sites, definitive conclusions as to the impact of Project related activities on Glossy Black Cockatoo habitat and activity cannot be drawn due to the absence of control sites.

2. Survey methods

2.1 Survey sites

Site locations are shown in Figure 1. As in the two previous monitoring events, the following four sites were surveyed in 2017:

- Kemps Access (ch. 17000).
- Ainsworth (also known as Seven Hills Road) (ch. 22600).
- Tamban (ch. 27000).
- Barraganyatti (ch. 33500).

2.2 Methodology

The survey method described within the EMP was employed for all surveys. Surveys were undertaken during May 2017.

2.2.1 Determining *Allocasuarina* stem and cone density

The location of individual quadrats are shown in Figure 2 to Figure 5. To address the patchy distribution of *Allocasuarina*, five 20 x 20 metre (400 m²) quadrats have been established within each site and assessed to derive a relative measure of average stem density for the entire stand. The locations of the five quadrats were established in 2014 and marked permanently with star pickets to aid in locating the same quadrat and repeating data collection in future monitoring surveys. At each quadrat, the following data were collected:

- Count of stems in three size classes according to height with:
 - 0-3 m considered immature or regenerating.
 - 3-6 m considered semi mature.
 - >6 m considered mature.
- Each stem was assessed to see whether it was bearing cones.
- Any incidental observations such as Glossy Black Cockatoo observations or chewed cones.

2.2.2 Determining the extent of foraging activity

To determine the extent of foraging activity, a traverse was undertaken within the vicinity of the quadrats, whereby the first 50 cone bearing *Allocasuarina* stems encountered within 10 m of the walked line (10 m either side) were assessed for foraging activity. The length of the traverse varied depending on the density of cone bearing *Allocasuarinas*. The traverses are shown in Figure 2 to Figure 5. Chewed cones were quantified using a subjective scale of:

- 0 = no chewed cones
- 1 = <25 chewed cones
- 2 = 26-100 chewed cones
- 3 = >100 chewed cones

As per the EMP, the following guide was used to measure the age of the chewed cones (Plate 1):

- White with green edges usually reflect foraging within the past 24 hours.
- Sandy or sawdust appearance reflect up to about 1 month.
- Russet or a rust colour usually reflect between 1-3 months.
- Brown colour approaching that of the seed's exterior is between 3-6 months.
- Grey colour represents an older cone with an undetermined age.



White with green edges
(0-24 hours)



Sand/sawdust
coloured
(1 day-4 weeks)



Brown coloured
(3-6 months)



Russet coloured
(1-3 months)



Grey coloured (age undetermined)

Plate 1: Chewed cone age indicating time since foraging

2.2.3 Other information

Other information collected during the survey includes:

- Glossy Black Cockatoo records at any of the monitoring sites.
- Signs of breeding activity in birds using the site (i.e. birds observed mating or using tree hollows).
- The extent and suitability of tree hollows in nearby areas (<500 metre).
- Distance to the nearest suitable water source.

3. Results

3.1 2017 monitoring results

A summary of the quadrat and traverse data collected during the autumn 2017 monitoring survey is presented in Table 1 and discussed in detail below. Field data for quadrats and traverses at each monitoring site are provided in Annex 1.

Table 1: *Allocasuarina* and Glossy Black Cockatoo 2017 data.

Attribute measured	Kemps Access	Ainsworth	Tamban	Barraganyatti
Date	22/05/2017	22/05/2017	23/05/2017	23/05/2017
Chainage	16900	22500	27000	33500
Average stem density (no./400m ²)	32 (SD = 5.9)	23 (SD = 13.3)	19 (SD = 7.8)	37 (SD = 11.5)
Average percent of stems bearing fruit (n = 5)	31%	28%	27%	15%
Percent of all stems (and stems with cones) with chewed cones within quadrats	4(14.6)%	7(26.5)%	0(0) %	2(14.8)%
Percent use of 50 cone-bearing stems	10%	12%	0%	6%

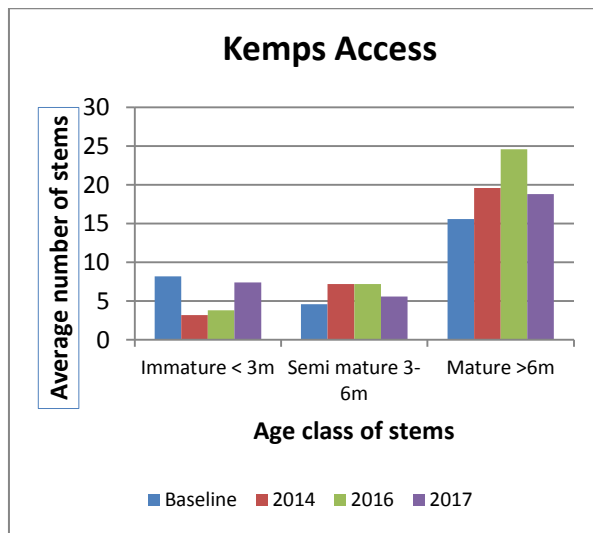
3.2 *Allocasuarina* stem density

The average number of *Allocasuarina* stem classes at each site is provided in Table 2. The average number of stems recorded for each age class in the 2013 (baseline), 2014, 2016 and 2017 monitoring events is provided for each site in Graph 1 to Graph 4. In 2017, as in the previous three monitoring events, mature stems were the most represented age class at all sites, with all age classes represented at all sites.

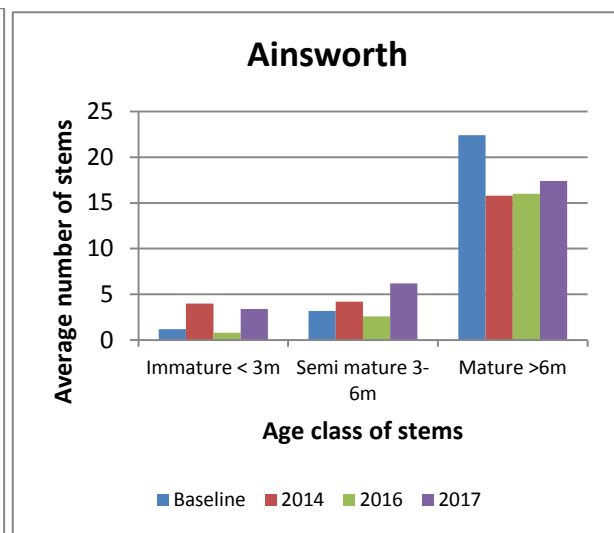
Due to the small sample size and non-normal distribution of the data, a nonparametric Wilcoxon Matched Pairs test was undertaken to compare baseline surveys with the 2017 monitoring event. No significant decline in average stem counts for each age class was detected for Kemps Access, Ainsworth and Barraganyatti. This test could not be performed for the Tamban site as baseline surveys were not undertaken at this site. However a comparison between 2014 and 2017 monitoring events was undertaken and no significant decline was detected.

Table 2: Stem density across sites

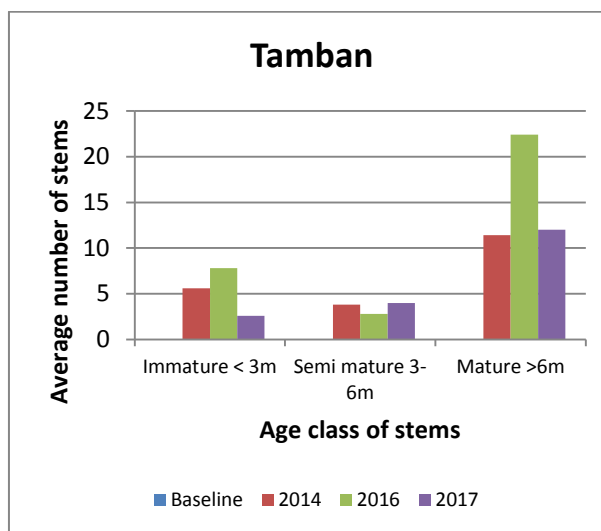
	Average number of stems (n = 5)				% of all stems	
	Immature <3m	Semi mature 3-6m	Mature >6m	Total	Mature >6m	Immature < 3m
Kemps Access	7.4	5.6	18.8	31.8	59%	23%
Ainsworth	3.4	6.2	17.4	27.0	64%	13%
Tamban	2.6	4	12	18.6	65%	14%
Barraganyatti	10.4	12.6	13.6	36.6	37%	28%



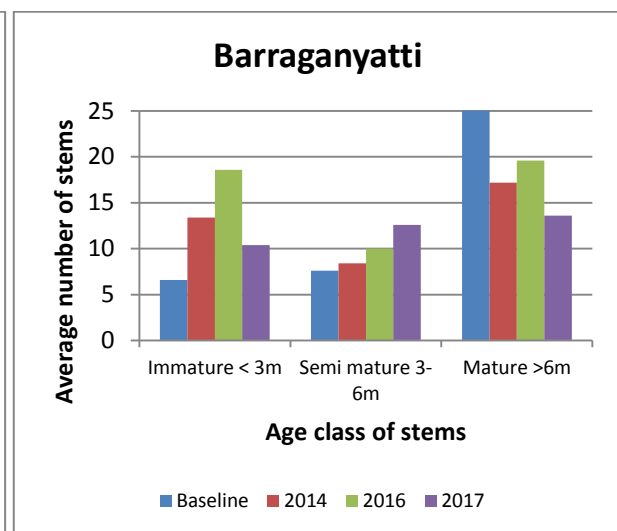
Graph 1: Kemps Access-average number of stems per quadrat



Graph 2: Ainsworth-average number of stems per quadrat



Graph 3: Tamaban-average number of stems per quadrat

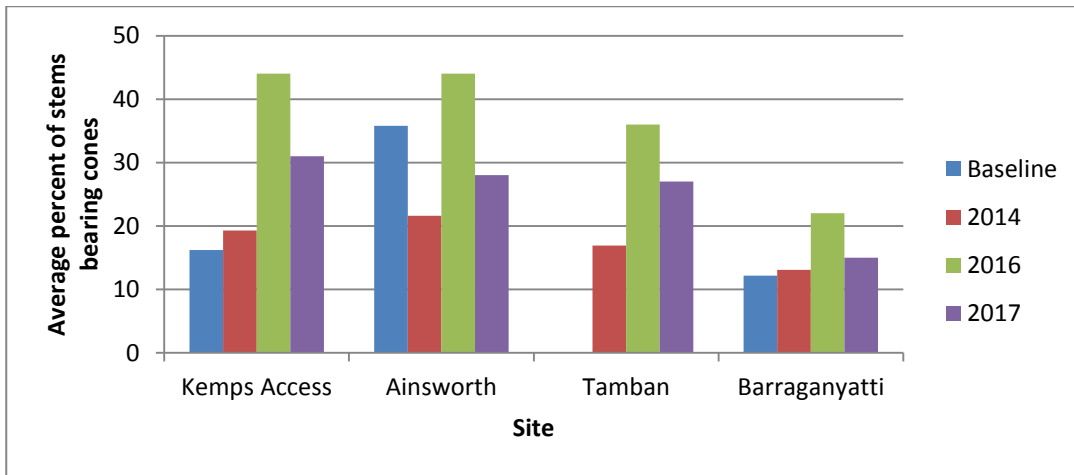


Graph 4: Barraganyatti-average number of stems per quadrat

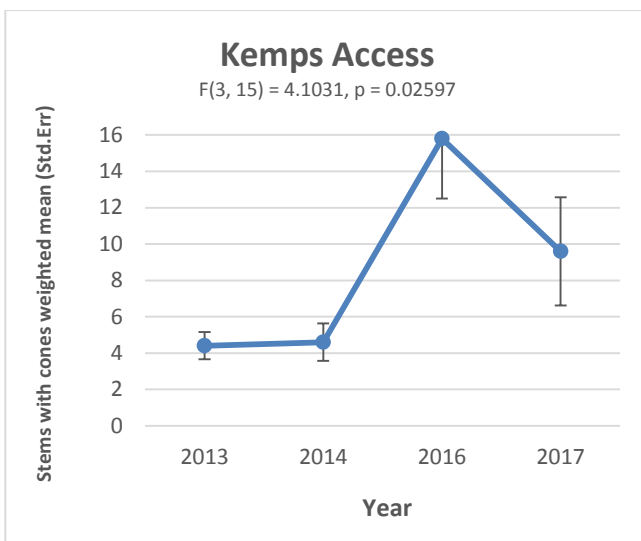
3.3 *Allocasuarina* cone density

3.3.1 Cone density in quadrats

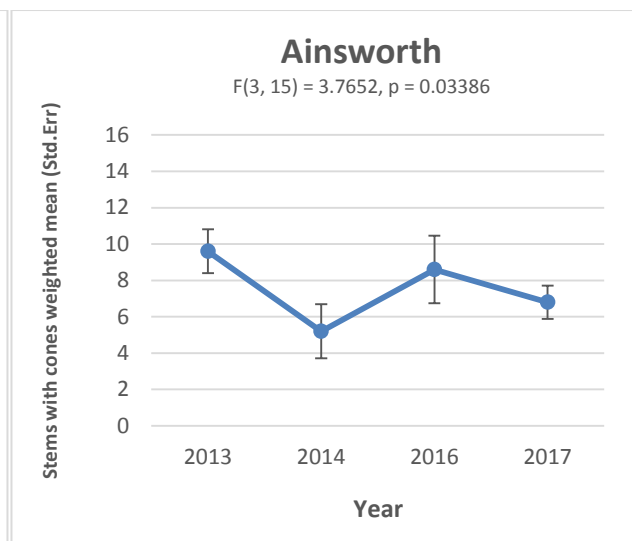
The average percentage of trees bearing cones from the five quadrats at each site in the different monitoring events is shown in Graph 5. The percentage of stems bearing cones was consistently higher in 2016 than in all other monitoring events. To assess differences in cone-bearing stems a GLM (generalised linear model), with year as the categorical factor, stems with cones as the variable and the total number of stems as the covariate, was undertaken to compare the number of stems with cones at each site. Results are presented in Graph 6 to Graph 9. While there was a significant variation in the number of stems bearing cones over the years for all sites except Barraganyatti, there was no directional trend. This result reinforces the natural fluctuation in foraging resources at any one location, indicating that a single change across years cannot necessarily be attributed to an impact or changing environment. A declining trend is not evident at this time.



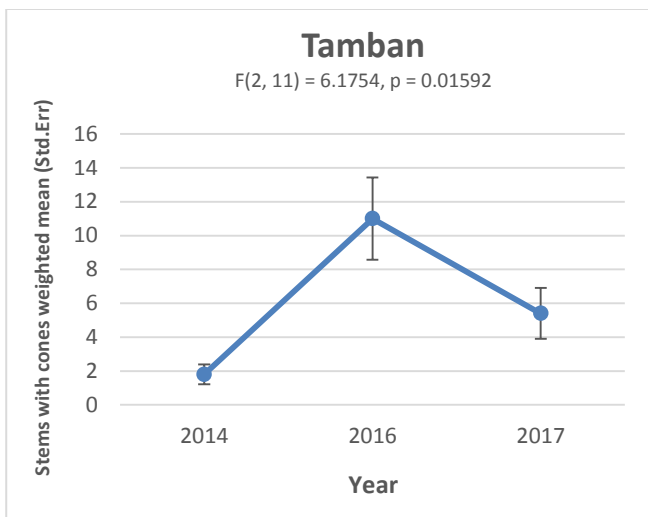
Graph 5: Average *Allocasuarina* cone frequency



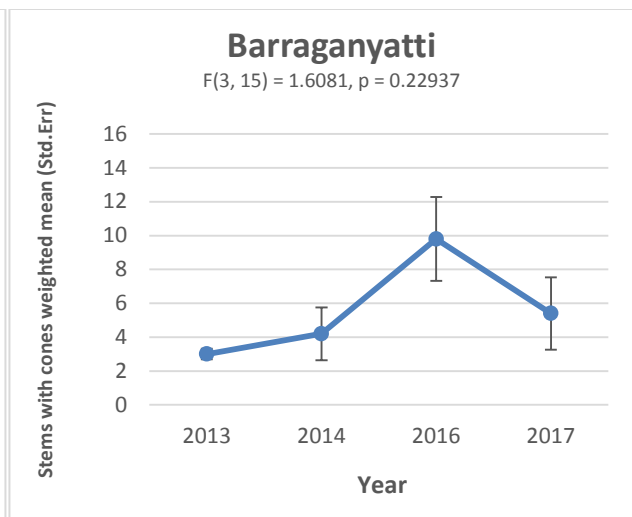
Graph 6: Kemps Access-weighted mean stems with cones



Graph 7: Ainsworth-weighted mean stems with cones



Graph 8: Tamban-weighted mean stems with cones

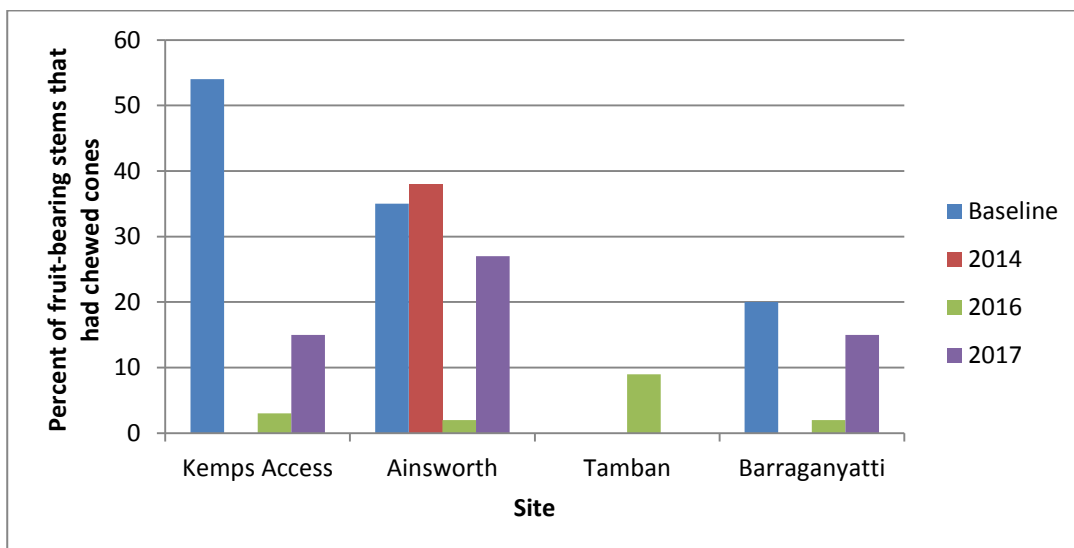


Graph 9: Barraganyatti-weighted mean stems with cones

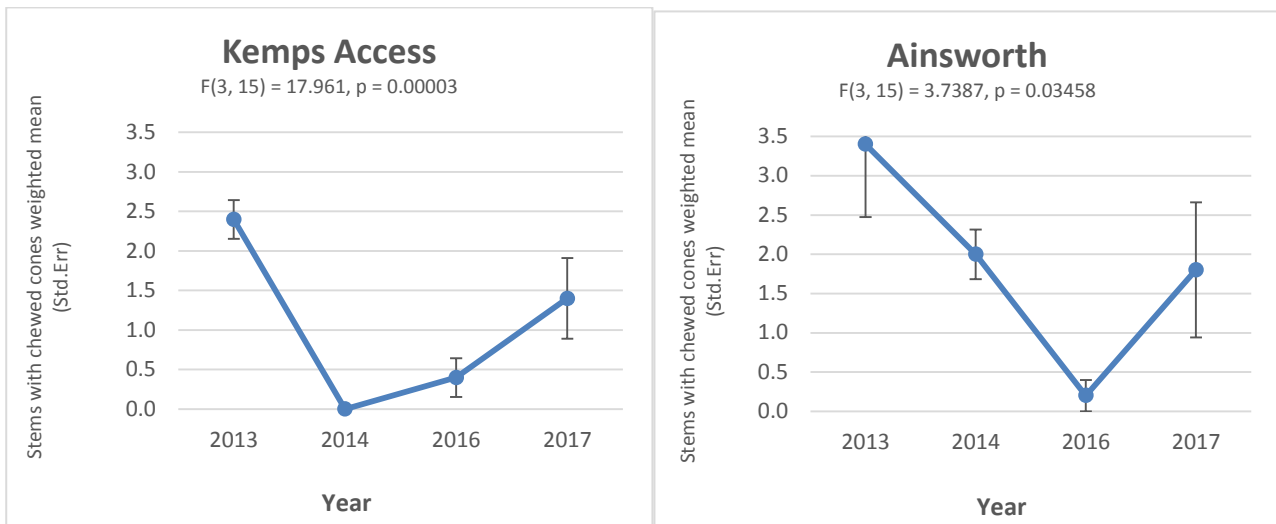
3.3.2 Chewed cones/foraging activity in quadrats

During 2017 monitoring, *Allocasuarina* stems bearing cones were recorded in every quadrat at all four sites, with three of the four sites showing signs of foraging activity (chewed cones on the ground) in at least three of the five quadrats. Only Tamban did not show signs of foraging within the surveyed quadrats. Graph 6 shows the percentage of fruit-bearing cones that showed signs of foraging (i.e. chewed cones) for each site.

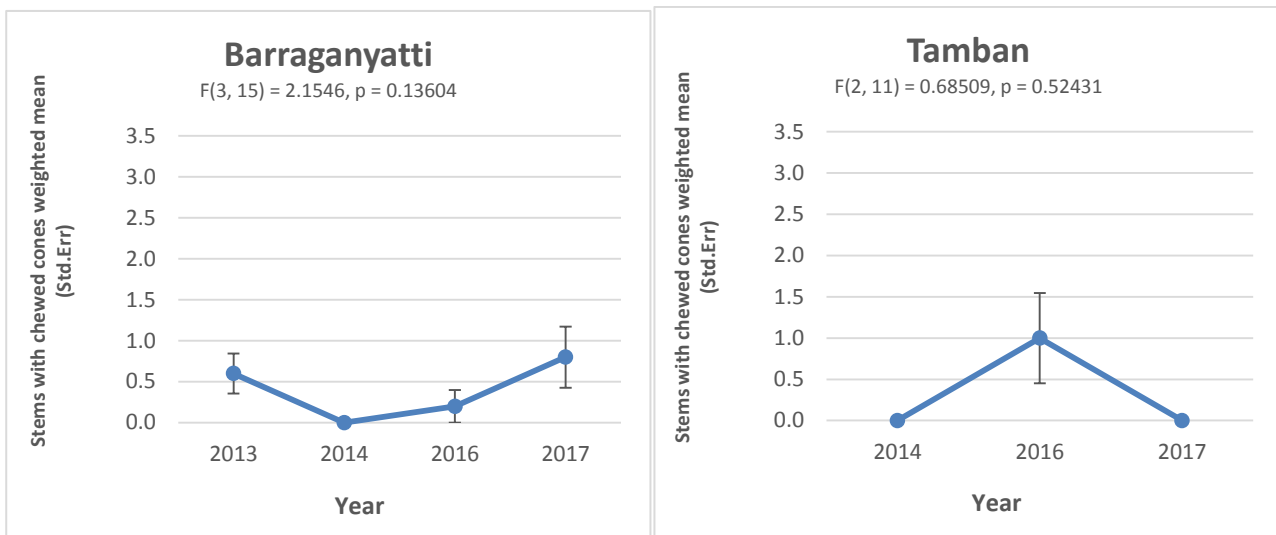
To assess differences in foraging activity, a GLM (year as categorical factor, stems with chewed cones as variable, total number of stems with cones as covariate), was undertaken to compare the number of stems with chewed cones at each site within quadrats. Results are presented in Graph 11 to Graph 14. Significant variations in foraging activity over the years were observed at Kemps Access and Ainsworth, (due notably to the high foraging activity recorded in baseline surveys), however, as for cone density, there was no directional trend. The presence of chewed cones varied greatly during the different monitoring events, however variability of specific foraging resource use is not unexpected as this species is known to forage over large areas and select favoured feed trees that have high seed return per cone (Clout 1989). This factor may vary from year to year with growth differences and foraging recovery. Foraging activity has been recorded at all sites within the quadrats during at least one monitoring event since baseline surveys, indicating the ongoing use of these sites for foraging. A declining trend is not evident at this time.



Graph 10: Percent use of fruit-bearing stems within quadrats



Graph 11: Kemps Access-weighted mean stems with chewed cones Graph 12: Ainsworth-weighted mean stems with chewed cones



Graph 13: Barraganyatti-weighted mean stems with chewed cones Graph 14: Tamban-weighted mean stems with chewed cones

3.4 Extent of foraging activity

Foraging activity determined along traverses of the first 50 cone-bearing stems is provided in Table 3. Graph 15 to Graph 18 show the number and distribution of chewed cones among age classes. During baseline surveys cones of varying age classes for individual stems were often recorded, resulting in multiple counts for single stems. To permit comparison of baseline data with monitoring data (where only a single age class was recorded for each of the first 50 cone-bearing stems) the youngest (most recent activity) age class record for each stem where cones were chewed was included in the analysis.

While the number of stems assessed and the method of assessment has remained constant throughout the monitoring events, the location of the assessment has varied. These changes in location preclude the use comparative statistical analyses intended to detect a site-specific decline in foraging activity. Changes in foraging activity were calculated between the baseline surveys and the 2017 monitoring using a chi-square test (Table 3), however these differences represent a difference in foraging between locations as opposed to a difference across years, or decline in use of the same resources.

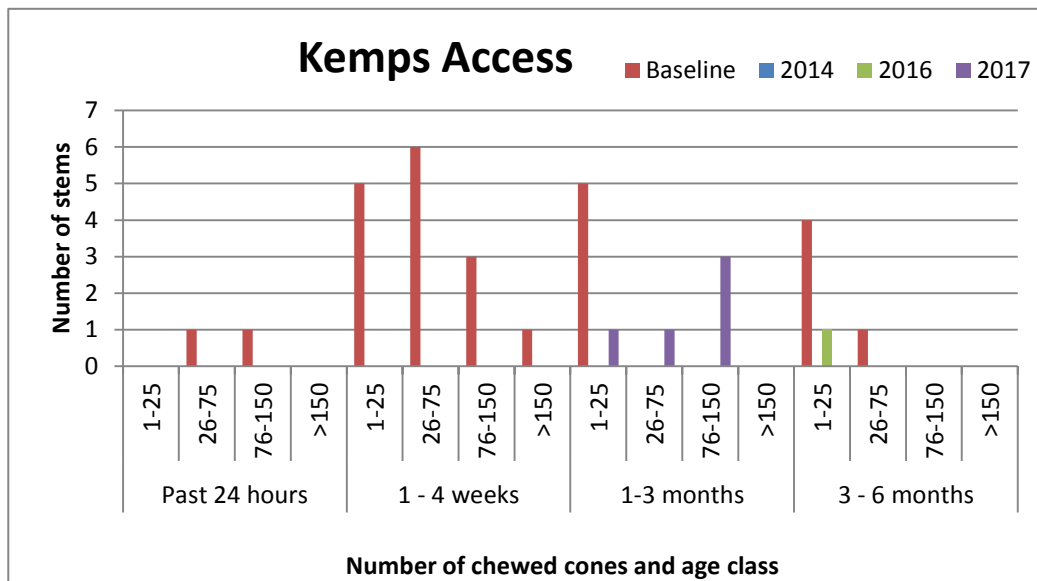
Only minimal foraging activity was recorded in each of the four areas in 2017, as in 2014 and 2016. Foraging activity was recorded at three of the four sites, with Tamban showing no signs of foraging from the 50 stems encountered within the traverse, nor within the quadrats. Tamban has consistently shown low foraging activity in previous monitoring events with no foraging activity at this site in 2014 and only at 3 (out of 50) trees in 2016 (no baseline data for this site).

A substantial decline has been observed at all baseline sites since baseline surveys. Monitoring surveys in 2014, 2016 and 2017 (including two construction surveys and one operational) however, recorded a relatively consistent level of foraging activity with variability between sites and years. Foraging activity has been recorded at all sites on at least one occasion.

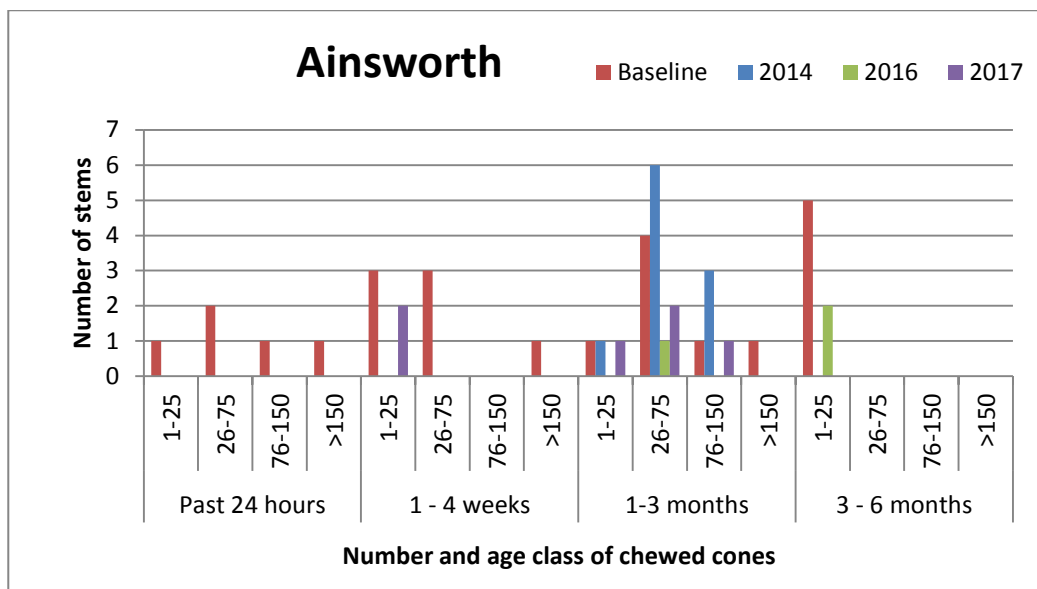
Table 3: Foraging activity during all monitoring events: 50 first stem-bearing traverses

	Stems with chewed cones				Chi-square (df = 1)	Traverse foraging activity (n = 50)			
	Baseline	2014	2016	2017	Baseline/2017	Baseline	2014	2016	2017
Kemps Access	27	0	1	5	22.24 p < 0001	54%	0%	2%	10%
Ainsworth	24	10	3	6	15.43 p < 0.001	48%	20%	6%	12%
Tamban	NA	0	4	0	NA	NA	0%	8%	0%
Barraganyatti	12	0	2	3	6.35 p = 0.12	24%	0%	4%	6%

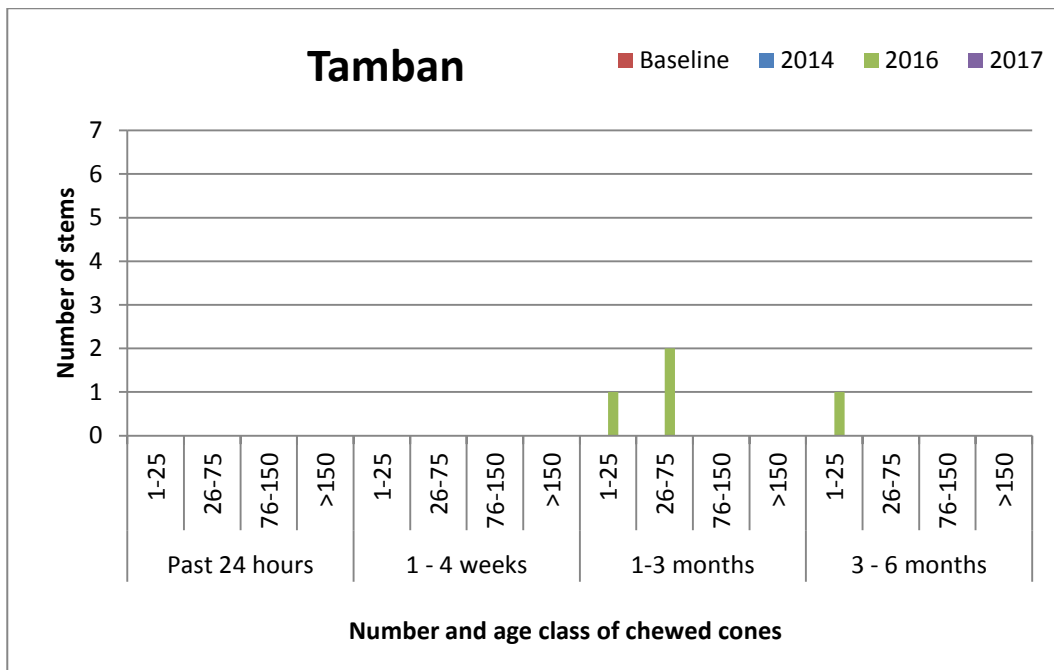
NA = not applicable as Tamban was not surveyed during baseline surveys



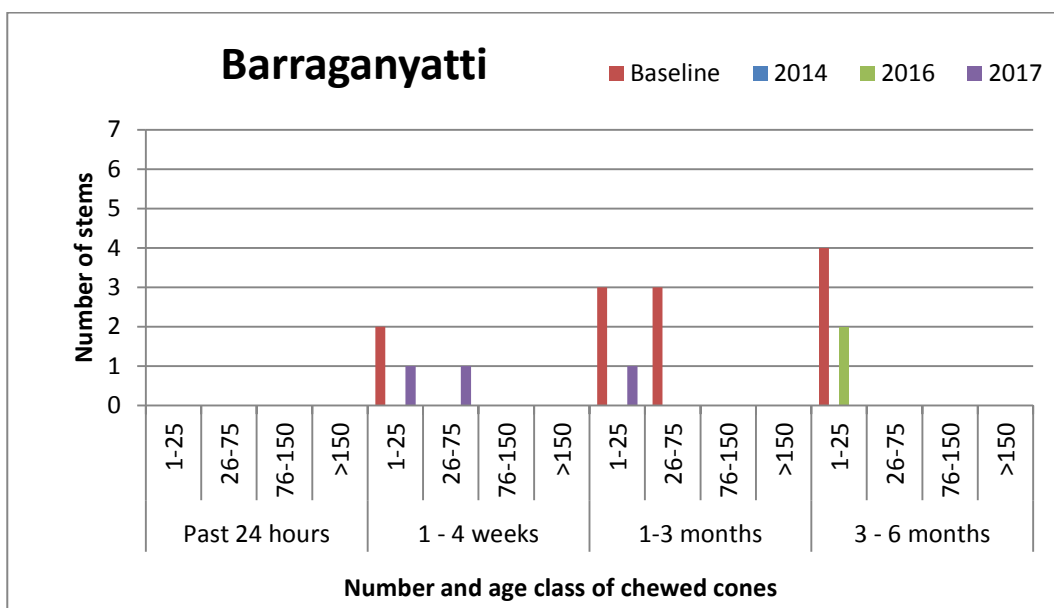
Graph 15: Foraging activity at Kemps Access



Graph 16: Foraging activity at Ainsworth



Graph 17: Foraging activity at Tamban



Graph 18: Foraging activity at Barraganyatti

3.5 Other observations

Glossy Black Cockatoos have been observed on numerous occasions during the current and previous surveys indicating continued use of the area as described below

3.5.3 Bird observations

Two Glossy Black Cockatoos were heard calling and then observed feeding just outside Quadrat 5 at Kemps Access in 2017.

Additional observations were made by Niche ecologists while undertaking other surveys in 2017. Two Glossy Black Cockatoos were observed west of the Pacific Highway, adjacent to the Barraganyatti site, and pairs of Glossy Black Cockatoos were heard calling at Ainsworth on two separate occasions.

In previous surveys one Glossy Black Cockatoo was heard calling and then observed flying above the canopy at Barraganyatti in 2016. No observations were made of Glossy Black Cockatoos during the 2014 monitoring surveys.

Results of the baseline surveys (Lewis 2014) included observations of birds at the Kemps Access and Ainsworth sites and birds in the vicinity of the Tamban and Barraganyatti sites.

3.5.4 Breeding signs

No signs of breeding were observed in any of the four survey sites during the 2017 monitoring, nor during the baseline, 2014 and 2016 monitoring events.

3.5.5 Extent and suitability of tree hollows

A number of suitable hollows were identified during baseline surveys. To compensate for the loss of hollows as a result of the Project, nest boxes have been installed in the area in accordance with the EMP. Fifteen nest boxes suitable for Glossy Black Cockatoos were installed in the vicinity of the Project and are shown in Figure 6. To date however, Glossy Black Cockatoos have not been recorded using these nest boxes (Niche 2017b).

3.5.6 Nearest watering points

A number of dams were identified as possible watering points during baseline surveys. These dams provide an ongoing resource that may vary with rainfall.

4. Discussion

4.1 Performance measures

A summary of 2017 survey results, and an overall assessment including the 2014, 2016 monitoring events, in relation to the performance measures is provided in Table 4 and Table 5. As baseline surveys did not include Tamban, only Kemps Access, Ainsworth and Barraganyatti have been considered in the assessment below.

Table 4: Performance indicators of success

Performance indicator	Discussion
Glossy Black Cockatoo using <i>Allocasuarina</i> resources to a similar extent (i.e. $p > 0.05$) as the baseline survey.	<p>This performance indicator of success cannot be assessed using traverse data as different traverses were surveyed. The use of different traverses precludes a stem-specific statistical comparison of foraging activity. While a substantial decrease in foraging activity was observed between baseline and monitoring surveys, monitoring surveys in 2014, 2016 and 2017 showed a relatively consistent level of foraging activity at all sites.</p> <p>Using quadrat data this performance indicator of success has been met for all sites. While significant variations in foraging activity were observed across years there is no evidence of a directional declining trend in foraging activity at this stage.</p>
Continued survival of <i>Allocasuarina</i> .	<p>This performance indicator of success was met in 2014 and 2016 and has been met in 2017. Multiple stands of <i>Allocasuarina</i> are still present and significant reductions in stem counts were not detected.</p>
Regeneration/recruitment of <i>Allocasuarina</i> .	<p>This performance indicator of success was met in 2014 and 2016 and has been met in 2017. Regeneration and recruitment was recorded at all sites and within the majority of quadrats.</p>

Table 5: Performance indicators of failure

Performance indicators	Discussion
Significantly (ANOVA $P < 0.05$) lower levels of <i>Allocasuarina</i> use compared to the baseline survey.	<p>This performance indicator of failure cannot be assessed using traverse data as different traverses were surveyed. The use of different traverses precludes a stem-specific statistical comparison of foraging activity. A substantial decrease in foraging activity was observed over the years, however monitoring surveys showed a relatively consistent level of foraging activity at all sites.</p> <p>Using quadrat data this performance indicator of failure has not been met for all sites. While significant variations in foraging activity were observed across years there is no evidence of a directional declining trend in foraging activity at this stage.</p>
No regeneration of <i>Allocasuarina</i> .	<p>This performance indicator of failure was not met in 2014 and 2016 has not been met in 2017. Regeneration and recruitment was recorded at all sites and within the majority of quadrats.</p>

5. Recommendations

5.1 Contingency measures

The EMP lists potential problems and contingency measures for various components of the monitoring program. Those that are considered to be relevant to the Glossy Black Cockatoo monitoring program are listed and discussed in Table 6.

Table 6: Contingency measures

Potential problem	Contingency measure proposed in EMP	Discussion
Significantly lower rates ($p < 0.05$) of foraging activity recorded between the baseline survey and monitoring events	Collect seed from regularly used trees and propagate to promote regeneration of more productive plants	This contingency measure is not considered relevant. While significant variations in foraging activity were observed across years there is no evidence of a directional declining trend in foraging activity at this stage.
Significantly lower fruiting rates in one or more areas	Review opportunities to provide <i>Allocasuarina</i> within rehabilitation schedule	This contingency measure is not considered relevant. There was no significant decline in cone density from baseline surveys at the baseline sites.
Significantly lower regeneration rates of <i>Allocasuarina</i>	Review and investigate management actions to promote regeneration	This contingency measure is not considered relevant. There was no significant decline in the presence of immature stems from baseline surveys at the baseline sites.

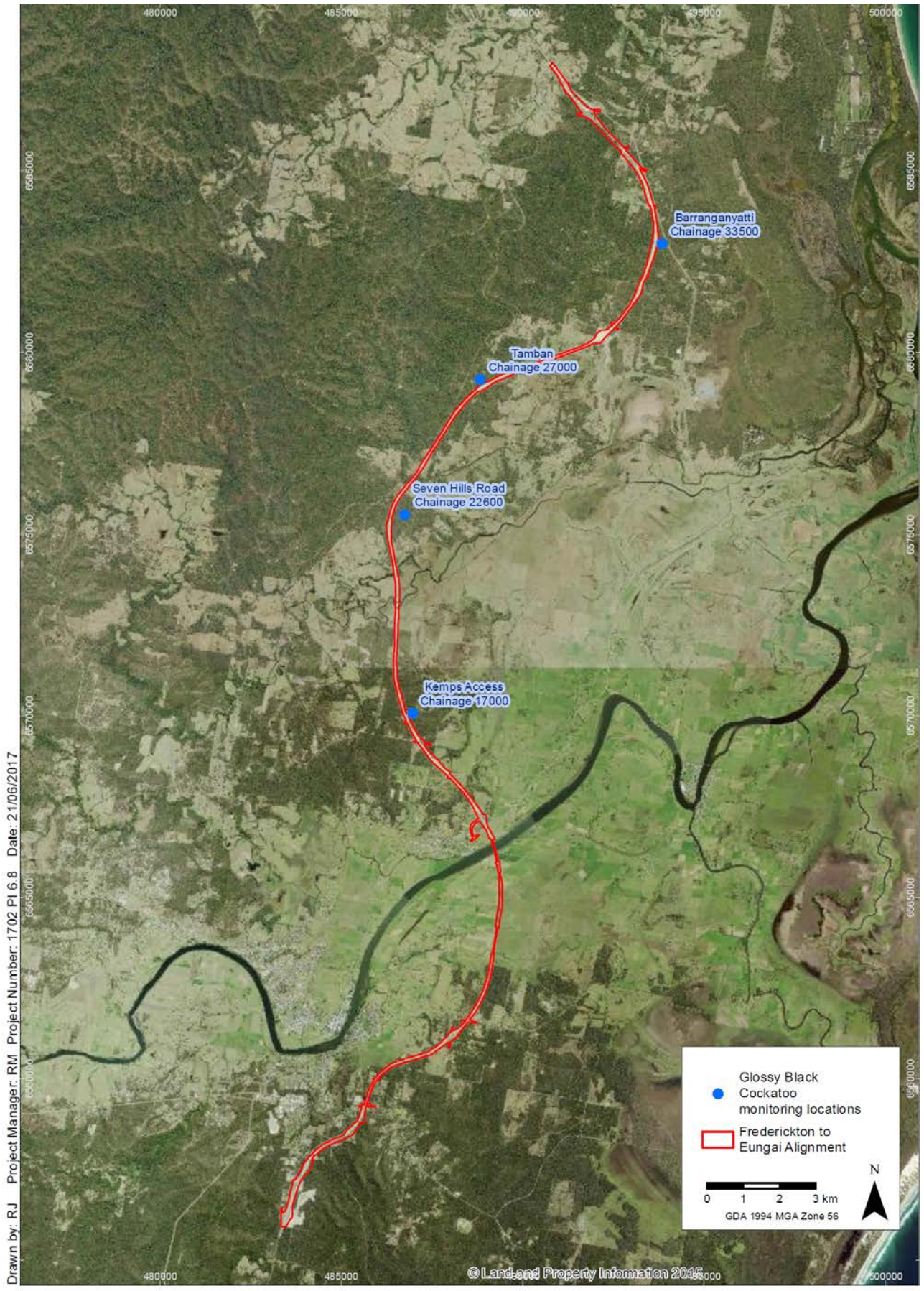
5.2 Recommendations

The Glossy Black Cockatoo monitoring program has found no directional declining trends in *Allocasuarina* regeneration, foraging resources or foraging activity at the four monitored sites. Variation in these factors over the years are considered to be due to natural fluctuations in the environment and Glossy Black Cockatoo behaviour. However the absence of control sites for comparison prevents definitive conclusions regarding the role of Project activities in the overall availability of foraging resources and level of foraging activity at the sites.

There are no recommendations for continued monitoring of these sites as performance measures, as defined in the EMP, have been met. However, if continued monitoring was considered for these sites it would be necessary to establish control sites. The inclusion of control sites would provide a comparison of overall levels between impact and control sites to determine if in fact Project activities were impacting the Glossy Black Cockatoo's resources and behaviour. Without control sites, impacts can only be determined with ongoing long-term monitoring to identify declining trends as opposed to short-term natural fluctuations.

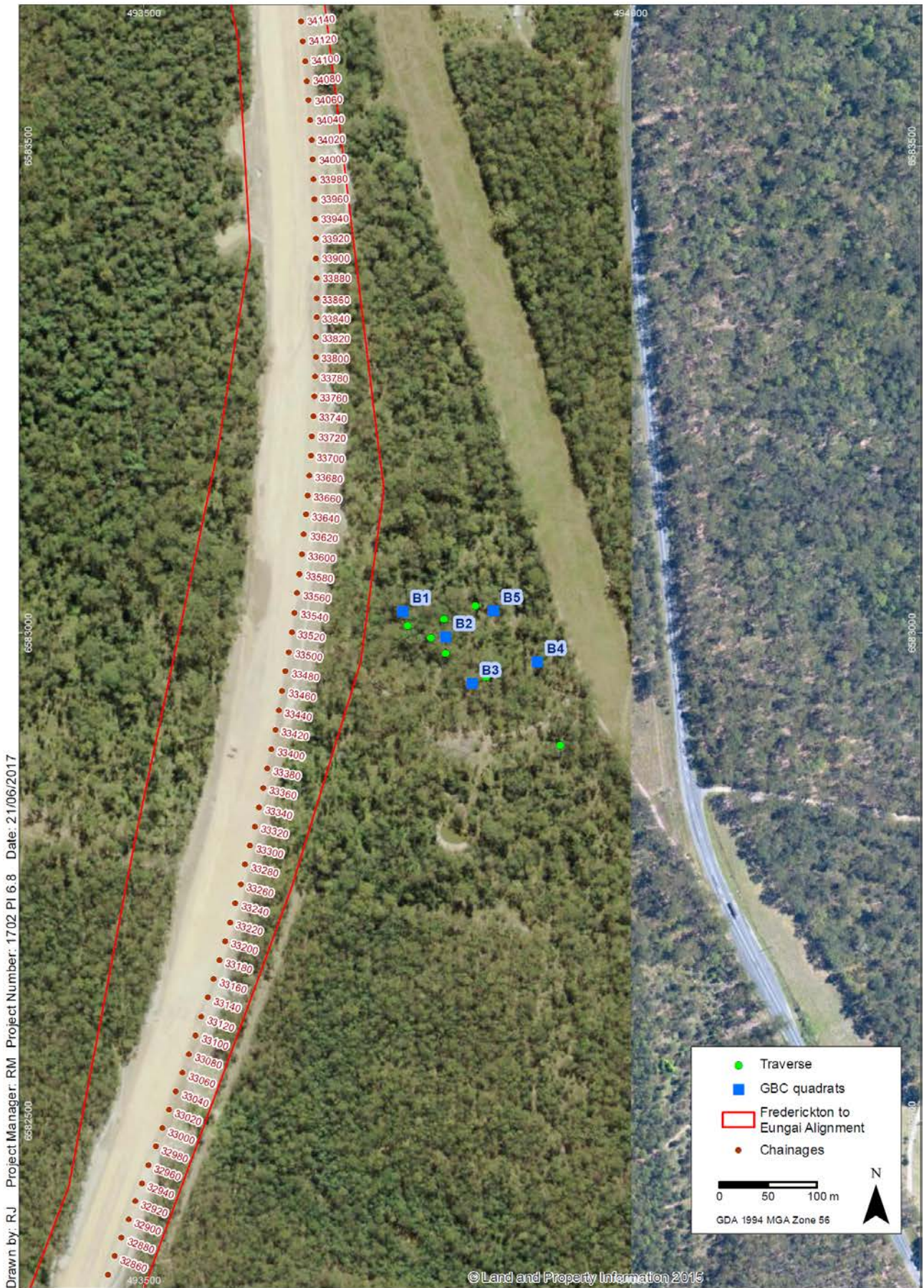
6. References

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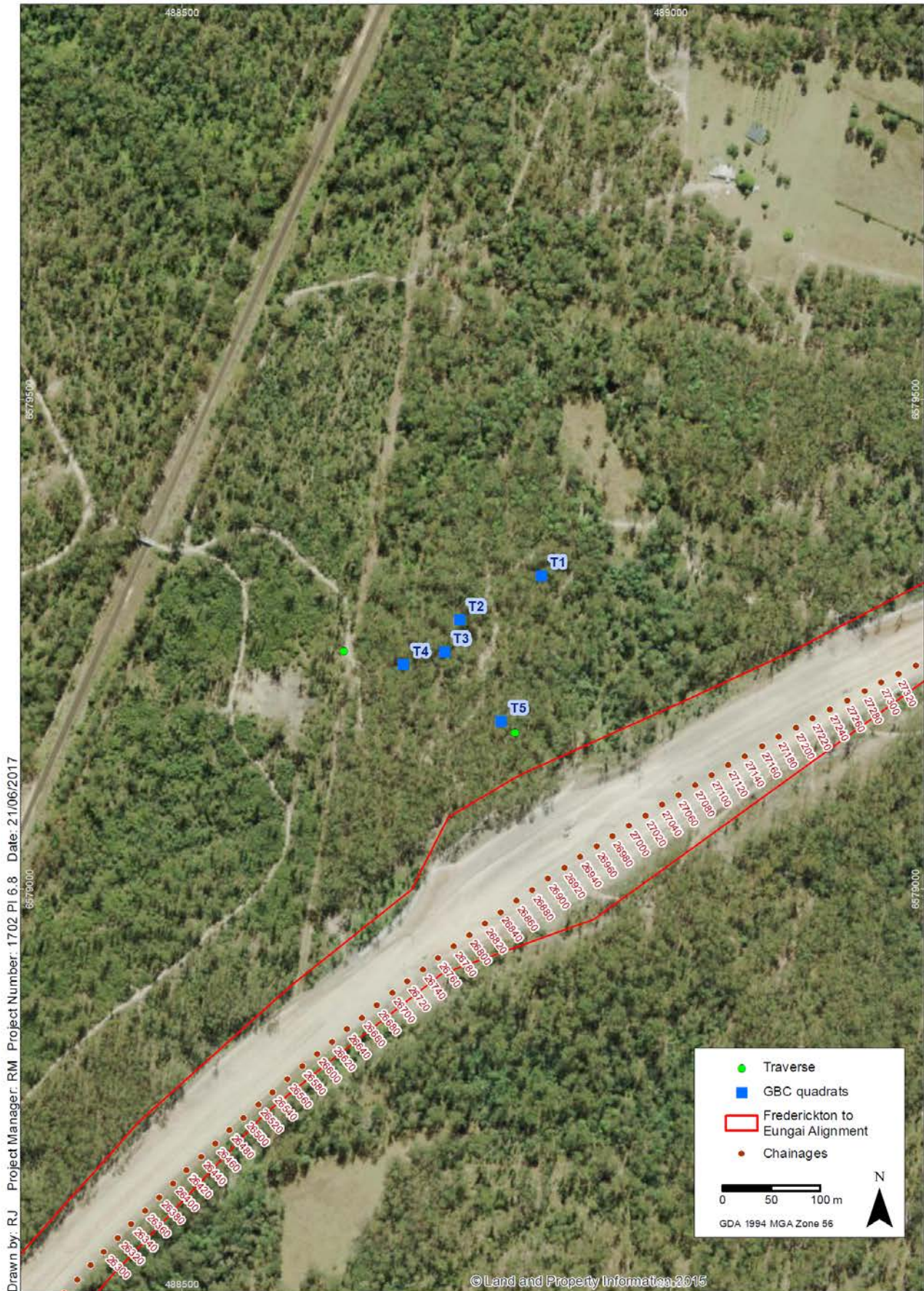
Glossy Black Cockatoo Monitoring Locations: overview
Pacific Highway Upgrade Frederickton to Eungai

FIGURE 1



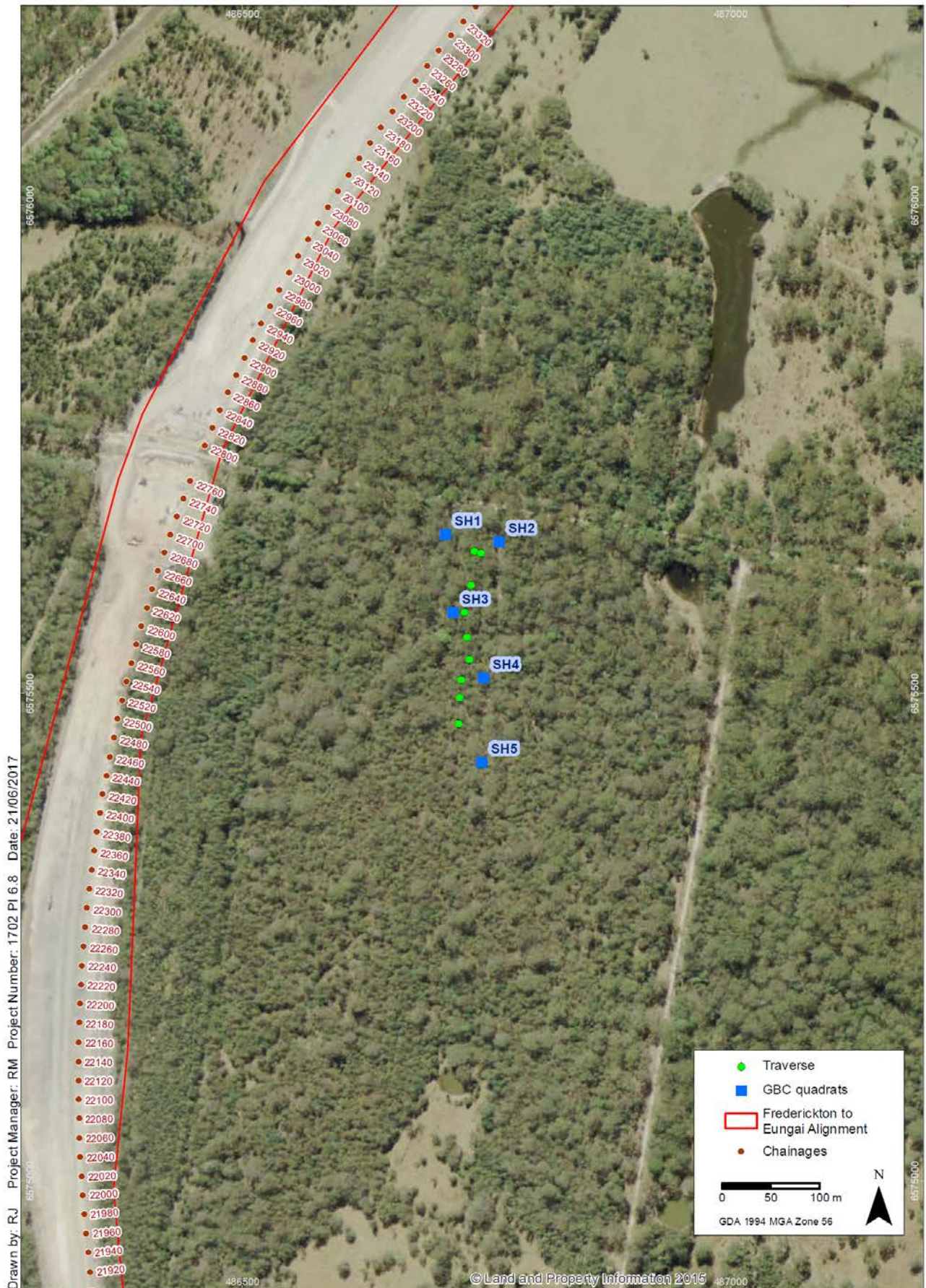
Glossy Black Cockatoo Monitoring: Barranganyatti
Pacific Highway Upgrade Frederickton to Eungai

FIGURE 2



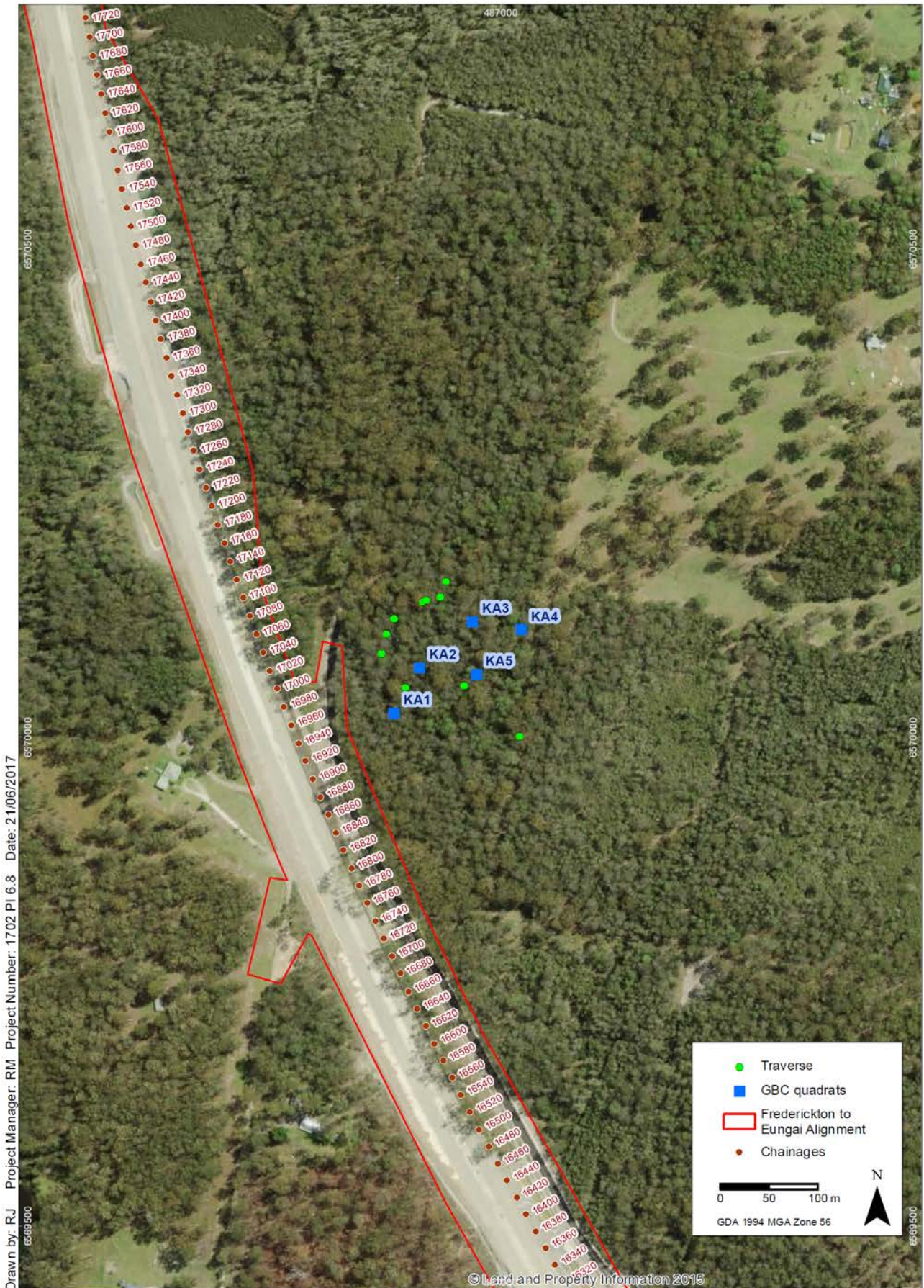
Glossy Black Cockatoo Monitoring: Tamban Pacific Highway Upgrade Frederickton to Eungai

FIGURE 3

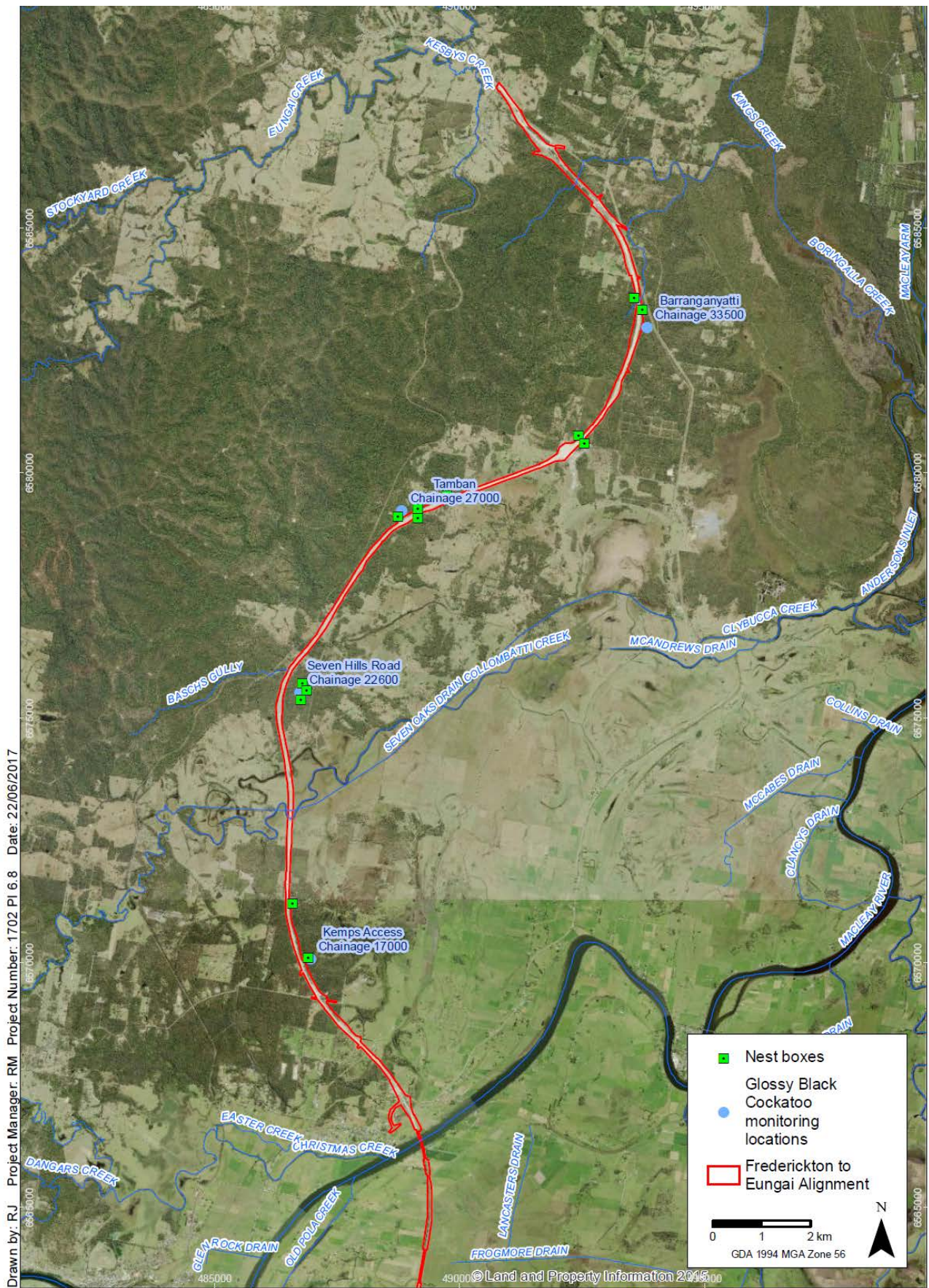


Glossy Black Cockatoo Monitoring: Seven Hills Road
Pacific Highway Upgrade Frederickton to Eungai

FIGURE 4



Glossy Black Cockatoo Monitoring: Kemps Access
Pacific Highway Upgrade Frederickton to Eungai



Drawn by: R.J. Project Manager: RM. Project Number: 1702.PI.6.8 Date: 22/06/2017

Glossy Black Cockatoo Habitat Features
Pacific Highway Upgrade Frederickton to Eungai

Annex 1. Autumn 2017 monitoring data

Quadrat data

Site	Date	Quadrat	Allocauari na species present	Stem size classes			Stems bearing cones/fruits			Stems with chewed cones			Observation
				0-3m	3-6m	>6m	0-3m	3-6m	>6m	0-3m	3-6m	>6m	
Kemps Access	22/05/2017	1	<i>A.torulosa</i>	8	11	15			6			0	
Kemps Access	22/05/2017	2	<i>A.torulosa</i>	2	8	26			19			3	
Kemps Access	22/05/2017	3	<i>A.torulosa</i>	13	3	22			6			2	
Kemps Access	22/05/2017	4	<i>A.torulosa</i>	11	1	14			3			1	
Kemps Access	22/05/2017	5	<i>A.torulosa</i>	3	5	17			14			1	Pair observed foraging adjacent
Ainsworth	22/05/2017	1	<i>A.torulosa</i>	3	9	15			5			0	
Ainsworth	22/05/2017	2	<i>A.torulosa</i>	2	15	21			7			1	
Ainsworth	22/05/2017	3	<i>A.torulosa</i>	1	4	17			7			1	
Ainsworth	22/05/2017	4	<i>A.torulosa</i>	11	3	23			10			5	
Ainsworth	22/05/2017	5	<i>A.torulosa</i>	0	0	11			5			2	
Tamban	23/05/2017	1	<i>A.torulosa</i>	6	7	10			8			0	
Tamban	23/05/2017	2	<i>A.torulosa</i>	3	5	12			3			0	
Tamban	23/05/2017	3	<i>A.torulosa</i>	1	2	11			6			0	
Tamban	23/05/2017	4	<i>A.torulosa</i>	0	5	23			9			0	
Tamban	23/05/2017	5	<i>A.torulosa</i>	3	1	4			1			0	
Barraganyatti	23/05/2017	1	<i>A.torulosa</i>	10	7	15			9			2	
Barraganyatti	23/05/2017	2	<i>A.torulosa</i>	10	25	16			2			0	
Barraganyatti	23/05/2017	3	<i>A.torulosa</i>	7	6	7			2			0	
Barraganyatti	23/05/2017	4	<i>A.torulosa</i>	7	11	22			12			1	
Barraganyatti	23/05/2017	5	<i>A.torulosa</i>	18	14	8			2			1	

Traverse data

Site	Date	No.	Species	Stem size classes	Fruits	Foraging activity scale	Time since foraging
Kemps Access	22/05/2017	1	<i>A.torulosa</i>	>6	Yes		
Kemps Access	22/05/2017	2	<i>A.torulosa</i>	>6	Yes		
Kemps Access	22/05/2017	3	<i>A.torulosa</i>	>6	Yes	3	1-3mth
Kemps Access	22/05/2017	4	<i>A.torulosa</i>	>6	Yes		
Kemps Access	22/05/2017	5	<i>A.torulosa</i>	>6	Yes		
Kemps Access	22/05/2017	6	<i>A.torulosa</i>	>6	Yes		
Kemps Access	22/05/2017	7	<i>A.torulosa</i>	3-6	Yes		
Kemps Access	22/05/2017	8	<i>A.torulosa</i>	3-6	Yes		
Kemps Access	22/05/2017	9	<i>A.torulosa</i>	>6	Yes		
Kemps Access	22/05/2017	10	<i>A.torulosa</i>	>6	Yes		
Kemps Access	22/05/2017	11	<i>A.torulosa</i>	>6	Yes		
Kemps Access	22/05/2017	12	<i>A.torulosa</i>	>6	Yes		
Kemps Access	22/05/2017	13	<i>A.torulosa</i>	>6	Yes		
Kemps Access	22/05/2017	14	<i>A.torulosa</i>	>6	Yes		
Kemps Access	22/05/2017	15	<i>A.torulosa</i>	>6	Yes		
Kemps Access	22/05/2017	16	<i>A.torulosa</i>	>6	Yes		
Kemps Access	22/05/2017	17	<i>A.torulosa</i>	>6	Yes		
Kemps Access	22/05/2017	18	<i>A.torulosa</i>	>6	Yes		
Kemps Access	22/05/2017	19	<i>A.torulosa</i>	>6	Yes		
Kemps Access	22/05/2017	20	<i>A.torulosa</i>	>6	Yes		
Kemps Access	22/05/2017	21	<i>A.torulosa</i>	>6	Yes		
Kemps Access	22/05/2017	22	<i>A.torulosa</i>	>6	Yes		
Kemps Access	22/05/2017	23	<i>A.torulosa</i>	>6	Yes		
Kemps Access	22/05/2017	24	<i>A.torulosa</i>	>6	Yes		
Kemps Access	22/05/2017	25	<i>A.torulosa</i>	>6	Yes		
Kemps Access	22/05/2017	26	<i>A.torulosa</i>	>6	Yes		
Kemps Access	22/05/2017	27	<i>A.torulosa</i>	>6	Yes		
Kemps Access	22/05/2017	28	<i>A.torulosa</i>	>6	Yes		
Kemps Access	22/05/2017	29	<i>A.torulosa</i>	>6	Yes		
Kemps Access	22/05/2017	30	<i>A.torulosa</i>	>6	Yes		
Kemps Access	22/05/2017	31	<i>A.torulosa</i>	>6	Yes		
Kemps Access	22/05/2017	32	<i>A.torulosa</i>	>6	Yes		
Kemps Access	22/05/2017	33	<i>A.torulosa</i>	>6	Yes		
Kemps Access	22/05/2017	34	<i>A.torulosa</i>	>6	Yes		
Kemps Access	22/05/2017	35	<i>A.torulosa</i>	>6	Yes		
Kemps Access	22/05/2017	36	<i>A.torulosa</i>	>6	Yes		
Kemps Access	22/05/2017	37	<i>A.torulosa</i>	>6	Yes	2	1-3mth
Kemps Access	22/05/2017	38	<i>A.torulosa</i>	>6	Yes		
Kemps Access	22/05/2017	39	<i>A.torulosa</i>	>6	Yes		
Kemps Access	22/05/2017	40	<i>A.torulosa</i>	>6	Yes		
Kemps Access	22/05/2017	41	<i>A.torulosa</i>	>6	Yes		
Kemps Access	22/05/2017	42	<i>A.torulosa</i>	>6	Yes	3	1-3mth

Site	Date	No.	Species	Stem size classes	Fruits	Foraging activity scale	Time since foraging
Kemps Access	22/05/2017	43	<i>A.torulosa</i>	>6	Yes		
Kemps Access	22/05/2017	44	<i>A.torulosa</i>	>6	Yes		
Kemps Access	22/05/2017	45	<i>A.torulosa</i>	3-6	Yes		
Kemps Access	22/05/2017	46	<i>A.torulosa</i>	>6	Yes	3	1-3mth
Kemps Access	22/05/2017	47	<i>A.torulosa</i>	>6	Yes	1	1-3mth
Kemps Access	22/05/2017	48	<i>A.torulosa</i>	>6	Yes		
Kemps Access	22/05/2017	49	<i>A.torulosa</i>	>6	Yes		
Kemps Access	22/05/2017	50	<i>A.torulosa</i>	>6	Yes		
			<i>A.torulosa</i>				
Ainsworth	22/05/2017	1	<i>A.torulosa</i>	>6	Yes	0	
Ainsworth	22/05/2017	2	<i>A.torulosa</i>	>6	Yes	0	
Ainsworth	22/05/2017	3	<i>A.torulosa</i>	>6	Yes	0	
Ainsworth	22/05/2017	4	<i>A.torulosa</i>	>6	Yes	0	
Ainsworth	22/05/2017	5	<i>A.torulosa</i>	>6	Yes	0	
Ainsworth	22/05/2017	6	<i>A.torulosa</i>	>6	Yes	0	
Ainsworth	22/05/2017	7	<i>A.torulosa</i>	>6	Yes	0	
Ainsworth	22/05/2017	8	<i>A.torulosa</i>	>6	Yes	0	
Ainsworth	22/05/2017	9	<i>A.torulosa</i>	>6	Yes	0	
Ainsworth	22/05/2017	10	<i>A.torulosa</i>	>6	Yes	0	
Ainsworth	22/05/2017	11	<i>A.torulosa</i>	>6	Yes	0	
Ainsworth	22/05/2017	12	<i>A.torulosa</i>	>6	Yes	0	
Ainsworth	22/05/2017	13	<i>A.torulosa</i>	>6	Yes	0	
Ainsworth	22/05/2017	14	<i>A.torulosa</i>	>6	Yes	0	
Ainsworth	22/05/2017	15	<i>A.torulosa</i>	>6	Yes	0	
Ainsworth	22/05/2017	16	<i>A.torulosa</i>	>6	Yes	0	
Ainsworth	22/05/2017	17	<i>A.torulosa</i>	>6	Yes	0	
Ainsworth	22/05/2017	18	<i>A.torulosa</i>	>6	Yes	2	1-3mth
Ainsworth	22/05/2017	19	<i>A.torulosa</i>	>6	Yes	0	
Ainsworth	22/05/2017	20	<i>A.torulosa</i>	>6	Yes	0	
Ainsworth	22/05/2017	21	<i>A.torulosa</i>	>6	Yes	0	
Ainsworth	22/05/2017	22	<i>A.torulosa</i>	>6	Yes	1	1 mth
Ainsworth	22/05/2017	23	<i>A.torulosa</i>	>6	Yes	0	
Ainsworth	22/05/2017	24	<i>A.torulosa</i>	>6	Yes	0	
Ainsworth	22/05/2017	25	<i>A.torulosa</i>	>6	Yes	1	1 mth
Ainsworth	22/05/2017	26	<i>A.torulosa</i>	>6	Yes	0	
Ainsworth	22/05/2017	27	<i>A.torulosa</i>	>6	Yes	0	
Ainsworth	22/05/2017	28	<i>A.torulosa</i>	>6	Yes	2	1-3mth
Ainsworth	22/05/2017	29	<i>A.torulosa</i>	>6	Yes	0	
Ainsworth	22/05/2017	30	<i>A.torulosa</i>	>6	Yes	0	
Ainsworth	22/05/2017	31	<i>A.torulosa</i>	>6	Yes	0	
Ainsworth	22/05/2017	32	<i>A.torulosa</i>	>6	Yes	0	
Ainsworth	22/05/2017	33	<i>A.torulosa</i>	>6	Yes	0	
Ainsworth	22/05/2017	34	<i>A.torulosa</i>	>6	Yes	0	

Site	Date	No.	Species	Stem size classes	Fruits	Foraging activity scale	Time since foraging
Ainsworth	22/05/2017	35	<i>A.torulosa</i>	>6	Yes	0	
Ainsworth	22/05/2017	36	<i>A.torulosa</i>	>6	Yes	0	
Ainsworth	22/05/2017	37	<i>A.torulosa</i>	>6	Yes	0	
Ainsworth	22/05/2017	38	<i>A.torulosa</i>	>6	Yes	0	
Ainsworth	22/05/2017	39	<i>A.torulosa</i>	>6	Yes	0	
Ainsworth	22/05/2017	40	<i>A.torulosa</i>	>6	Yes	0	
Ainsworth	22/05/2017	41	<i>A.torulosa</i>	>6	Yes	1	1-3mth
Ainsworth	22/05/2017	42	<i>A.torulosa</i>	>6	Yes	0	
Ainsworth	22/05/2017	43	<i>A.torulosa</i>	>6	Yes	0	
Ainsworth	22/05/2017	44	<i>A.torulosa</i>	>6	Yes	0	
Ainsworth	22/05/2017	45	<i>A.torulosa</i>	>6	Yes	0	
Ainsworth	22/05/2017	46	<i>A.torulosa</i>	>6	Yes	0	
Ainsworth	22/05/2017	47	<i>A.torulosa</i>	>6	Yes	0	
Ainsworth	22/05/2017	48	<i>A.torulosa</i>	>6	Yes	0	
Ainsworth	22/05/2017	49	<i>A.torulosa</i>	>6	Yes	0	
Ainsworth	22/05/2017	50	<i>A.torulosa</i>	>6	Yes	3	1-3mth
Tamban	23/05/2017	1	<i>A.torulosa</i>	>6	Yes	0	
Tamban	23/05/2017	2	<i>A.torulosa</i>	>6	Yes		
Tamban	23/05/2017	3	<i>A.torulosa</i>	>6	Yes		
Tamban	23/05/2017	4	<i>A.torulosa</i>	3-6	Yes		
Tamban	23/05/2017	5	<i>A.torulosa</i>	>6	Yes		
Tamban	23/05/2017	6	<i>A.torulosa</i>	>6	Yes		
Tamban	23/05/2017	7	<i>A.torulosa</i>	>6	Yes		
Tamban	23/05/2017	8	<i>A.torulosa</i>	>6	Yes		
Tamban	23/05/2017	9	<i>A.torulosa</i>	>6	Yes		
Tamban	23/05/2017	10	<i>A.torulosa</i>	>6	Yes		
Tamban	23/05/2017	11	<i>A.torulosa</i>	>6	Yes		
Tamban	23/05/2017	12	<i>A.torulosa</i>	>6	Yes		
Tamban	23/05/2017	13	<i>A.torulosa</i>	>6	Yes		
Tamban	23/05/2017	14	<i>A.torulosa</i>	>6	Yes		
Tamban	23/05/2017	15	<i>A.torulosa</i>	>6	Yes		
Tamban	23/05/2017	16	<i>A.torulosa</i>	>6	Yes		
Tamban	23/05/2017	17	<i>A.torulosa</i>	>6	Yes		
Tamban	23/05/2017	18	<i>A.torulosa</i>	>6	Yes		
Tamban	23/05/2017	19	<i>A.torulosa</i>	>6	Yes		
Tamban	23/05/2017	20	<i>A.torulosa</i>	>6	Yes		
Tamban	23/05/2017	21	<i>A.torulosa</i>	>6	Yes		
Tamban	23/05/2017	22	<i>A.torulosa</i>	>6	Yes		
Tamban	23/05/2017	23	<i>A.torulosa</i>	>6	Yes		
Tamban	23/05/2017	24	<i>A.torulosa</i>	>6	Yes		
Tamban	23/05/2017	25	<i>A.torulosa</i>	>6	Yes		
Tamban	23/05/2017	26	<i>A.torulosa</i>	>6	Yes		
Tamban	23/05/2017	27	<i>A.torulosa</i>	>6	Yes		

Site	Date	No.	Species	Stem size classes	Fruits	Foraging activity scale	Time since foraging
Tamban	23/05/2017	28	<i>A.torulosa</i>	>6	Yes		
Tamban	23/05/2017	29	<i>A.torulosa</i>	>6	Yes		
Tamban	23/05/2017	30	<i>A.torulosa</i>	>6	Yes		
Tamban	23/05/2017	31	<i>A.torulosa</i>	3-6	Yes		
Tamban	23/05/2017	32	<i>A.torulosa</i>	>6	Yes		
Tamban	23/05/2017	33	<i>A.torulosa</i>	>6	Yes		
Tamban	23/05/2017	34	<i>A.torulosa</i>	>6	Yes		
Tamban	23/05/2017	35	<i>A.torulosa</i>	>6	Yes		
Tamban	23/05/2017	36	<i>A.torulosa</i>	>6	Yes		
Tamban	23/05/2017	37	<i>A.torulosa</i>	>6	Yes		
Tamban	23/05/2017	38	<i>A.torulosa</i>	>6	Yes		
Tamban	23/05/2017	39	<i>A.torulosa</i>	>6	Yes		
Tamban	23/05/2017	40	<i>A.torulosa</i>	>6	Yes		
Tamban	23/05/2017	41	<i>A.torulosa</i>	>6	Yes		
Tamban	23/05/2017	42	<i>A.torulosa</i>	>6	Yes		
Tamban	23/05/2017	43	<i>A.torulosa</i>	>6	Yes		
Tamban	23/05/2017	44	<i>A.torulosa</i>	>6	Yes		
Tamban	23/05/2017	45	<i>A.torulosa</i>	>6	Yes		
Tamban	23/05/2017	46	<i>A.torulosa</i>	>6	Yes		
Tamban	23/05/2017	47	<i>A.torulosa</i>	>6	Yes		
Tamban	23/05/2017	48	<i>A.torulosa</i>	>6	Yes		
Tamban	23/05/2017	49	<i>A.torulosa</i>	>6	Yes		
Tamban	23/05/2017	50	<i>A.torulosa</i>	>6	Yes		
Barraganyatti	23/05/2017	1	<i>A.torulosa</i>	>6	Yes		
Barraganyatti	23/05/2017	2	<i>A.torulosa</i>	>6	Yes		
Barraganyatti	23/05/2017	3	<i>A.torulosa</i>	>6	Yes		
Barraganyatti	23/05/2017	4	<i>A.torulosa</i>	>6	Yes	1	1 mth
Barraganyatti	23/05/2017	5	<i>A.torulosa</i>	>6	Yes		
Barraganyatti	23/05/2017	6	<i>A.torulosa</i>	>6	Yes		
Barraganyatti	23/05/2017	7	<i>A.torulosa</i>	>6	Yes		
Barraganyatti	23/05/2017	8	<i>A.torulosa</i>	>6	Yes		
Barraganyatti	23/05/2017	9	<i>A.torulosa</i>	>6	Yes		
Barraganyatti	23/05/2017	10	<i>A.torulosa</i>	>6	Yes		
Barraganyatti	23/05/2017	11	<i>A.torulosa</i>	>6	Yes		
Barraganyatti	23/05/2017	12	<i>A.torulosa</i>	>6	Yes		
Barraganyatti	23/05/2017	13	<i>A.torulosa</i>	>6	Yes		
Barraganyatti	23/05/2017	14	<i>A.torulosa</i>	>6	Yes		
Barraganyatti	23/05/2017	15	<i>A.torulosa</i>	>6	Yes		
Barraganyatti	23/05/2017	16	<i>A.torulosa</i>	>6	Yes		
Barraganyatti	23/05/2017	17	<i>A.torulosa</i>	>6	Yes		
Barraganyatti	23/05/2017	18	<i>A.torulosa</i>	>6	Yes	2	1 mth
Barraganyatti	23/05/2017	19	<i>A.torulosa</i>	>6	Yes		
Barraganyatti	23/05/2017	20	<i>A.torulosa</i>	>6	Yes		

Site	Date	No.	Species	Stem size classes	Fruits	Foraging activity scale	Time since foraging
Barraganyatti	23/05/2017	21	<i>A.torulosa</i>	>6	Yes		
Barraganyatti	23/05/2017	22	<i>A.torulosa</i>	>6	Yes		
Barraganyatti	23/05/2017	23	<i>A.torulosa</i>	>6	Yes		
Barraganyatti	23/05/2017	24	<i>A.torulosa</i>	>6	Yes		
Barraganyatti	23/05/2017	25	<i>A.torulosa</i>	>6	Yes		
Barraganyatti	23/05/2017	26	<i>A.torulosa</i>	>6	Yes		
Barraganyatti	23/05/2017	27	<i>A.torulosa</i>	>6	Yes		
Barraganyatti	23/05/2017	28	<i>A.torulosa</i>	>6	Yes		
Barraganyatti	23/05/2017	29	<i>A.torulosa</i>	>6	Yes		
Barraganyatti	23/05/2017	30	<i>A.torulosa</i>	>6	Yes		
Barraganyatti	23/05/2017	31	<i>A.torulosa</i>	>6	Yes		
Barraganyatti	23/05/2017	32	<i>A.torulosa</i>	>6	Yes		
Barraganyatti	23/05/2017	33	<i>A.torulosa</i>	>6	Yes		
Barraganyatti	23/05/2017	34	<i>A.torulosa</i>	>6	Yes		
Barraganyatti	23/05/2017	35	<i>A.torulosa</i>	>6	Yes		
Barraganyatti	23/05/2017	36	<i>A.torulosa</i>	>6	Yes		
Barraganyatti	23/05/2017	37	<i>A.torulosa</i>	>6	Yes		
Barraganyatti	23/05/2017	38	<i>A.torulosa</i>	>6	Yes		
Barraganyatti	23/05/2017	39	<i>A.torulosa</i>	>6	Yes		
Barraganyatti	23/05/2017	40	<i>A.torulosa</i>	>6	Yes		
Barraganyatti	23/05/2017	41	<i>A.torulosa</i>	>6	Yes		
Barraganyatti	23/05/2017	42	<i>A.torulosa</i>	>6	Yes	1	1-3mth
Barraganyatti	23/05/2017	43	<i>A.torulosa</i>	>6	Yes		
Barraganyatti	23/05/2017	44	<i>A.torulosa</i>	>6	Yes		
Barraganyatti	23/05/2017	45	<i>A.torulosa</i>	>6	Yes		
Barraganyatti	23/05/2017	46	<i>A.torulosa</i>	>6	Yes		
Barraganyatti	23/05/2017	47	<i>A.torulosa</i>	>6	Yes		
Barraganyatti	23/05/2017	48	<i>A.torulosa</i>	3-6	Yes		
Barraganyatti	23/05/2017	49	<i>A.torulosa</i>	3-6	Yes		
Barraganyatti	23/05/2017	50	<i>A.torulosa</i>	>6	Yes		

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Appendix H Brush-tailed Phascogale



Brush-tailed Phascogale Monitoring 2017

Frederickton to Eungai Pacific Highway Upgrade

Prepared for Roads and Maritime Services

July 2017

Document control

Project no.: 1702 (PI 6.9)

Project client: Roads and Maritime Services

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Project Director: Rhidian Harrington

Project Manager: Radika Michniewicz

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Newcastle
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Port Macquarie
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Cairns

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Cover photograph: Brush-tailed Phascogale captured during the 2014 monitoring event (Photo: C. McLean) and image captured of individual using glider pole during autumn 2017.

Executive summary

Context

This report documents the third and final monitoring event for the Brush-tailed Phascogale (*Phascogale tapoatafa*) as required by the Frederickton to Eungai (F2E) Ecological Monitoring Program (RMS 2016).

Aims

The aims of this report are to summarise the methods and results of the autumn 2017 monitoring and provide an overall discussion of all monitoring events and to determine if performance measures have been met, as per the EMP (RMS 2016).

Methods

In accordance with the EMP, arboreal tree trapping was undertaken at three sites using a trap grid of ten tree mounted Elliott B traps in habitat immediately adjacent to the proposed fauna underpasses, with trap grids being set in place on both sides of the carriageway (a total of 20 traps at each site). Baited traps were positioned on brackets approximately two metres above the ground and the host tree was sprayed with a mixture of honey water and traps were left operating over four consecutive nights. Traps were checked within two hours of sunrise each morning and details of any Brush-tailed Phascogales captured were recorded, including trap location, sex, age, weight and breeding condition. Larger species that were captured (i.e. any arboreal marsupial greater than 100 grams in weight) were implanted with a passive integrated transponder.

Key results

No Phascogales were captured at any of the three sites during this monitoring event. Other native fauna captured included the Northern Brown Bandicoot (*Isodon macrourus*), Bush Rat (*Rattus fuscipes*), Brown Antechinus (*Antechinus stuartii*), Common Brushtail Possum (*Trichosurus vulpecula*) and Sugar Glider (*Petaurus breviceps*). One introduced species, the Black Rat (*Rattus Rattus*) was captured. One deceased Brush-tailed Phascogale was found in the underpass at Seven Hills Road, and one live individual in proximity to the Tamban site was recorded during other monitoring surveys (F2E aerial crossing monitoring).

Conclusions

Individuals were captured post-clearing at Seven Hills and Tamban in 2014, indicating the persistence of this species as this time. The Brush-tailed Phascogale was recorded at Seven Hills and Tamban in 2017 providing evidence that this species persists in proximity to the monitoring sites at the completion of the monitoring program.

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1. Introduction

1.1 Context

As part of Frederickton to Eungai (F2E) Pacific Highway Upgrade Project (the Project), Roads and Maritime Services (Roads and Maritime) have implemented an Ecological Monitoring Program (EMP) in accordance with the Minister for Planning's Condition of Approval (MCoA) No. 3.1. This Ecological Monitoring Program (EMP) (RMS 2016) combines the approval conditions provided within the Ministers Conditions of Approval (MCoA) and Statement of Commitments (SoC), and defines the mitigation and offsetting requirements for threatened species and ecological communities impacted by the Project.

The Brush-tailed Phascogale (*Phascogale tapoatafa*) was one threatened species identified as requiring mitigation and monitoring through the course of the Projects' construction and operational period. The monitoring requirements for this species are outlined within the approved EMP (RMS 2016).

1.1.1 Legal Status

The Brush-tailed Phascogale (*Phascogale tapoatafa*) is listed as vulnerable under the NSW *Threatened Species Conservation Act 1995* (TSC Act). Monitoring of the species is required under the Project's approval.

1.1.2 Monitoring framework

The approved EMP (RMS 2016) states the following regarding monitoring.

"Three monitoring events will be undertaken with the:

- *First monitoring event to occur within 12 months (autumn 2014) of habitat being removed to accommodate the carriageway.*
- *Second monitoring event to occur once additional fauna mitigation devices have been installed (i.e. fauna underpass, exclusion fencing) within 24 months or upon the operational phase of the project (autumn 2016).*
- *Third to occur once the carriageway is operational and at least 12 months later after the second monitoring event (autumn 2017)."*

To date, these monitoring events have been reported on as follows:

- *Autumn 2014:* Niche 2015.
- *Autumn 2016:* Niche 2017.
- *Autumn 2017:* current, and final, report.

The EMP provides for the evaluation of the need for successive monitoring based on the results of these monitoring events (RMS 2016).

1.1.3 Baseline data

The EMP (RMS 2016) provides the following baseline data for the Brush-tailed Phascogale monitoring program:

- Chainage 16900: One Phascogale recorded in 2001 immediately east of carriageway. Hair sample collected from western side of carriageway in 2003.
- **Chainage 22500 (Seven Hills Road): Seven individuals trapped over a 2 hectare grid in 2004.**
- Chainage 23100: Two Phascogales trapped 700 metres west in 2002.
- **Chainage 26600 (Tamban): Six individuals trapped over a 2 hectare grid in 2005.**

- Chainage 27400: Two individuals trapped over a 2 hectare grid in 2004.
- Chainage 36600: No Phascogales recorded but suitable habitat identified and recorded 1.5 kilometres to the south in Tamban State Forest.
- **Chainage 34400 (Barraganyatti): No Phascogales recorded but suitable habitat identified and recorded 1.5 kilometres to the west in Tamban State Forest.**

Those sites highlighted in bold, hereafter referred to as Seven Hills, Tamban, and Barraganyatti, were proposed as monitoring sites for the Brush-tailed Phascogale (RMS 2016).

1.1.4 Purpose of this Report

This report complies with the monitoring requirements described within the approved EMP (RMS 2016) and details the findings obtained from the third and final monitoring event.

The aims of this report are to summarise the methods and results of the autumn 2017 monitoring and provide an overall discussion of all monitoring events to determine if performance measures have been met, as per the EMP (RMS 2016).

1.2 Performance measures

The approved EMP specifies the following performance indicators for the Brush-tailed Phascogale (RMS 2016).

Performance indicators of successful mitigation will be based on:

- *Continued presence of Phascogale from known locations (Seven Hills and Tamban).*
- *Presence of Phascogale from a location which represents potential habitat (Barraganyatti).*

Signs of the mitigation being unsuccessful will be based on:

- *Absence of Phascogale from known locations (Seven Hills and Tamban).*

1.3 Monitoring timing

As per the EMP, monitoring was to be undertaken on three occasions; in autumn 2014, 2016 and 2017, with the third monitoring event occurring once the carriageway became operational (and at least 12 months after the 2016 monitoring event).

1.4 Reporting

The EMP states, annual reporting of monitoring results will outline:

- A description of the monitoring methodology employed.
- Results of the monitoring surveys.
- A discussion of the results, including how the results compare against key performance criteria.
- The need for any corrective actions/contingency measures and any general recommendations.

All reports prepared under the EMP are to be submitted to the Director General of the NSW Department of Planning and Environment and the NSW Environment Protection Authority (EPA).

2. Survey methods

2.1 Survey sites

Three sites were monitored (Figure 1) and detailed trapping locations for each site are provided in Figure 2, Figure 3 and Figure 4:

- Barraganyatti (Ch 34000) (Figure 2)
- Tamban (Ch 26600) (Figure 3)
- Seven Hills (Ch 22500) (Figure 4)

Seven Hills and Tamban were selected due to the high numbers of Brush-tailed Phascogales recorded during baseline surveys and Barraganyatti was deemed to provide suitable habitat, although Brush-tailed Phascogales have not been previously recorded here. These three sites were surveyed in baseline surveys in a manner consistent with that proposed within the EMP and are in the vicinity of fauna impact mitigation structures.

2.2 Survey method

Surveys were undertaken between 15 and 19 May 2017, approximately 12 months after the 2016 surveys (Niche 2017).

In accordance with the EMP, at each of the three sites arboreal tree trapping was undertaken using a trap grid of ten tree mounted Elliott B traps (providing approximately one ha coverage) in habitat immediately adjacent to the proposed fauna underpasses, with trap grids being set in place on both sides of the carriageway (a total of 20 traps at each site). In addition to each set of ten Elliott B traps, two cage traps were deployed to reduce the risk of Common Brushtail Possums (*Trichosurus vulpecula*) triggering the Elliott B traps, which occurred in previous monitoring events (Niche 2015). Catching these larger possums eliminates them from circulating for the night and setting off the Elliot B traps, allowing greater trapping opportunity for Brush-tailed Phascogales.

Elliott B traps were baited with a mixture of rolled oats, peanut butter and honey and were positioned on brackets approximately two metres above the ground. The host tree was sprayed with a mixture of honey water above the trap as an additional attractant. The traps were left operating over four consecutive nights. Traps were checked within two hours of sunrise each morning, bait was checked and trees were re-sprayed with honey water. The following details were recorded for any Brush-tailed Phascogales captured:

- trap location
- sex
- age class
- mass
- breeding condition.

Larger species that were captured (i.e. any arboreal marsupial greater than 100 grams in weight) were implanted with a passive integrated transponder (PIT) microchip. Due to their short life expectancy, Brown Antechinus (*Antechinus stuartii*) were not microchipped as they were unlikely to be recaptured in future monitoring events. Microchipping Phascogales provides the opportunity to collect information regarding recapture rates, locations of each capture, movement patterns of individuals within the landscape and in relation to impacts from the road, and changes in an individual's health and condition. The location and

identity of all other fauna captured was also recorded, along with information on health, sex and reproductive status, where this could be determined with minimal animal handling.

2.3 Analysis

Monitoring results are to be analysed in accordance with the performance indicators specified within the EMP. In the case of the Brush-tailed Phascogale performance measures are based on presence/absence results and do not require statistical comparison between survey events.

3. Results

3.1 Trapping

The results of the autumn 2017 surveys are presented in Tables 1-3. There were no Brush-tailed Phascogales captured during the 2017 monitoring event, however one deceased individual was found in the underpass at Seven Hills. The cause of death was unknown, with no visible injuries other than a small wound near the neck.

Other native fauna captured included the Northern Brown Bandicoot (*Isodon macrourus*), Bush Rat (*Rattus fuscipes*), Brown Antechinus (*Antechinus stuartii*), Common Brushtail Possum (*Trichosurus vulpecula*) and Sugar Glider (*Petaurus breviceps*). One introduced Black Rat (*Rattus Rattus*) was captured.

Despite deploying cage traps at each site, a number of Elliot traps were knocked off their frames and the bait removed during the course of the monitoring. Over the four trapping nights, one Elliot trap at Barraganyatti, five at Tamban, and six at Seven Hills were interfered with and had their baits removed.

A summary of all monitoring events compared with baseline data is provided in Table 4.

Table 1: Barraganyatti

Date	East/west Carriageway	Trap number [^]	Species	Recapture (Y/N)	Sex	Weight	Breeding condition	Microchip ID
16/05/2017	East	312 C	Bush Rat		F			
17/05/2017	East	302 C	Black Rat*		F			
17/05/2017	East	351 E	Brown Antechinus		M			
18/05/2017	East	361 E	Brown Antechinus		M			
18/05/2017	East	362 C	Bush Rat					
19/05/2017	East	361 E	Brown Antechinus					
19/05/2017	East	362 C	Bush Rat					

*Introduced species; [^]C = Cage trap, E = Elliot trap

Table 2: Tamban

Date	East/West Carriageway	Trap number [^]	Species	Recapture (Y/N)	Sex	Weight	Breeding condition	Microchip ID
16/05/2017	East	330 E	Sugar Glider	Y 6/04/2017 [#]	F	100 g	With pouch	0007A38588
17/05/2017	East	353 E	Sugar Glider	Y 16/05/2017	F	100 g	With pouch	0007A38588
17/05/2017	East	355 C	Northern Brown Bandicoot					
18/05/2017	East	364 E	Sugar Glider	Y 16/05/2017 17/05/2017	F	85 g	With pouch	0007A38588
19/05/2017	East	353 E	Brown					

Date	East/West Carriageway	Trap number [^]	Species	Recapture (Y/N)	Sex	Weight	Breeding condition	Microchip ID
			Antechinus					

[^]C = Cage trap, E = Elliot trap; #⁻ (aerial crossing monitoring tag 0007634DCCS)

Table 3: Seven Hills Road

Date	East/West Carriageway	Trap number [^]	Species	Recapture (Y/N)	Sex	Weight	Breeding condition	Microchip ID
15/05/2017	Near underpass		Brush-tailed Phascogale (deceased)	N	M	230 g		
18/05/2017	West	366 C	Common Brushtail Possum	N	F	1.49 kg	No pouch development	0007A398C7
18/05/2017	East	367 C	Common Brushtail Possum	N		2.22 kg		000791EA6E
19/05/2017	West	368 E	Brown Antechinus					
19/05/2017	West	369 C	Common Brushtail Possum	Y 18/05/2017	F			0007A398C7

[^]C = Cage trap, E = Elliot trap

Table 4: Monitoring summary

	Number of Phascogales captured		
	Seven Hills	Tamban	Barraganyatti
Baseline (2004-2005)	7	6	Nil
Monitoring event 1 (2014)	2	2*	Nil
Monitoring event 2 (2016)	Nil	Nil	Nil
Monitoring event 3 (2017)	1 deceased	1 additional observation	Nil

*Including one individual recaptured

3.2 Additional observations

As discussed in Niche 2015 and Niche 2017, results of other monitoring surveys undertaken by Niche in relation to F2E monitoring programs may provide relevant information regarding the presence of Brush-tailed Phascogales at the sites. While these surveys cannot be included as part of the monitoring program for this species as they have not been designed with this aim, they may provide anecdotal information via incidental observations.

Table 5 and Figure 5 present incidental observations of Brush-tailed Phascogales recorded during other monitoring surveys. Those records that fall within 500 m (Niche 2017) of an assumed boundary (500 m radius from a centre point), therefore a 1000 m radius from centre point of the three Brush-tailed Phascogale monitoring sites, are indicated in bold.

Only one of these records is in proximity to a monitoring site. The camera trap image of a Brush-tailed Phascogale on a glider pole is in proximity of the Tamban monitoring site and can therefore be considered as a value adding record for this site.

Table 5: Additional records

Year	Monitoring	Reference	Location (easting/northing)	< 500 m from BtPh site
2015	Summer Nest box	RMS 2015	487532 / 6568648	No
May 2017	Autumn Aerial crossing	Niche 2017 aerial crossing monitoring report – field surveys ongoing	489250 / 6579271	Tamban
Jan 2017	Summer Underpass – camera trap	Niche 2017 underpass monitoring report – in progress	486536 / 6572021	No
June 2017	Autumn Underpass - camera trap	Niche 2017 underpass monitoring report 2017 – in progress	486536 / 6572021	No
July 2017	Winter Nest box monitoring	Niche 2017 nest box monitoring report – in progress	488148 / 6568008	No

4. Discussion

4.1 Performance measures

A summary of the autumn 2017 survey results in relation to the performance indicators are provided in Table 6 and Table 7.

Table 6: Performance indicators of successful mitigation

Performance indicators of success	Discussion
Continued presence of Phascogale at Seven Hills and Tamban	This performance indicator has been met. Individuals were captured in 2014 and were identified via additional observations at these sites in 2017. The 2014 monitoring event was timed to provide an indication of any impact associated with clearing works. The successful captures in 2014 indicate a continued presence of Brush-tailed Phascogales post-clearing and additional observations at Seven Hills and Tamban in 2017 provide evidence that they are present in these areas.
Presence of Phascogale at Barraganyatti	This performance indicator has not been met. Phascogales have not been recorded during any monitoring event and were not recorded at this site during baseline surveys.

Table 7: Performance indicators of unsuccessful mitigation

Performance indicators of unsuccessful mitigation	Discussion
Absence of Phascogale at Seven Hills and Tamban	This performance indicator of unsuccessful mitigation has not been met. Phascogales were captured at Seven Hills and Tamban in 2014 and individuals were identified via additional observations at these sites in 2017.

5. Recommendations

5.1 Contingency measures

The EMP lists potential problems and contingency measures for various components of the monitoring program. Those that are considered to be relevant to the Brush-tailed Phascogale monitoring program are listed and discussed in Table 8.

Table 8: Contingency measures

Potential Problem	Contingency Measure proposed in EMP	Discussion of proposed measure
Absence of Phascogale from the monitoring program	Review/modify monitoring program to include different sampling techniques, survey of other areas.	The Phascogale has been recorded at two of the three monitoring sites and is therefore not considered as absent from the monitoring program. The absence of Phascogales from the Barraganyatti site is not considered as warranting contingency measures as this species was not recorded at this site during baseline surveys and cannot therefore be deemed as absent where previously present. This contingency measure is not considered relevant.

5.2 Evaluation of need for further monitoring

The EMP provides for the evaluation of the need for successive monitoring based on the results of the monitoring events (RMS 2016). This evaluation is discussed below and considers the results of all monitoring events and additional observations.

The first monitoring event was undertaken within 12 months of clearing to provide an indication of the potential influence of clearing works on the Brush-tailed Phascogale (RMS 2016). Individuals were captured post-clearing at Seven Hills and Tamban in 2014, indicating the persistence of this species at this time.

Further trapping surveys did not detect this species, however the Brush-tailed Phascogale is known to usually occur in low densities and to be very difficult to trap with certainty without significant survey effort. It is noteworthy that Lewis 2005 reports the use of multiple detection methods for the records obtained during baseline surveys (Elliott trapping, Arboreal trapping, Spotlighting, Stag watching and Hair tubes). If monitoring was to continue using the same trapping-only methodology, it is possible that the same results (lack of records/captures) could occur.

While trapping did not detect individuals in 2017, the presence of the deceased individual at Seven Hills and the additional observation of the live individual on the glider pole at Tamban provide evidence that this species persists in proximity to the monitoring sites at the completion of the monitoring program.

The additional observations of Brush-tailed Phascogales adjacent to the carriageway and to the south of the monitoring sites, while not in direct proximity to the monitoring sites, indicate the persistence of this threatened species in the broader area and in habitat adjacent to the carriageway.

It is therefore considered that continued monitoring of the Brush-tailed Phascogale is not necessary in order to meet the performance measures identified in the EMP (RMS 2016).

Considerations

If additional monitoring of Seven Hills and Tamban was considered as a means of more definitively verifying the persistence of a population at these sites, it is recommended that a more intense survey effort be applied to those specific sites (as per Lewis 2005) to increase the chance of detection.

6. References

Lewis, B.D. (2005). Kempsey to Eungai Pacific Highway Upgrade: Fauna Survey. Report prepared by Lewis Ecological Surveys for Parsons Brinckerhoff-Sydney.

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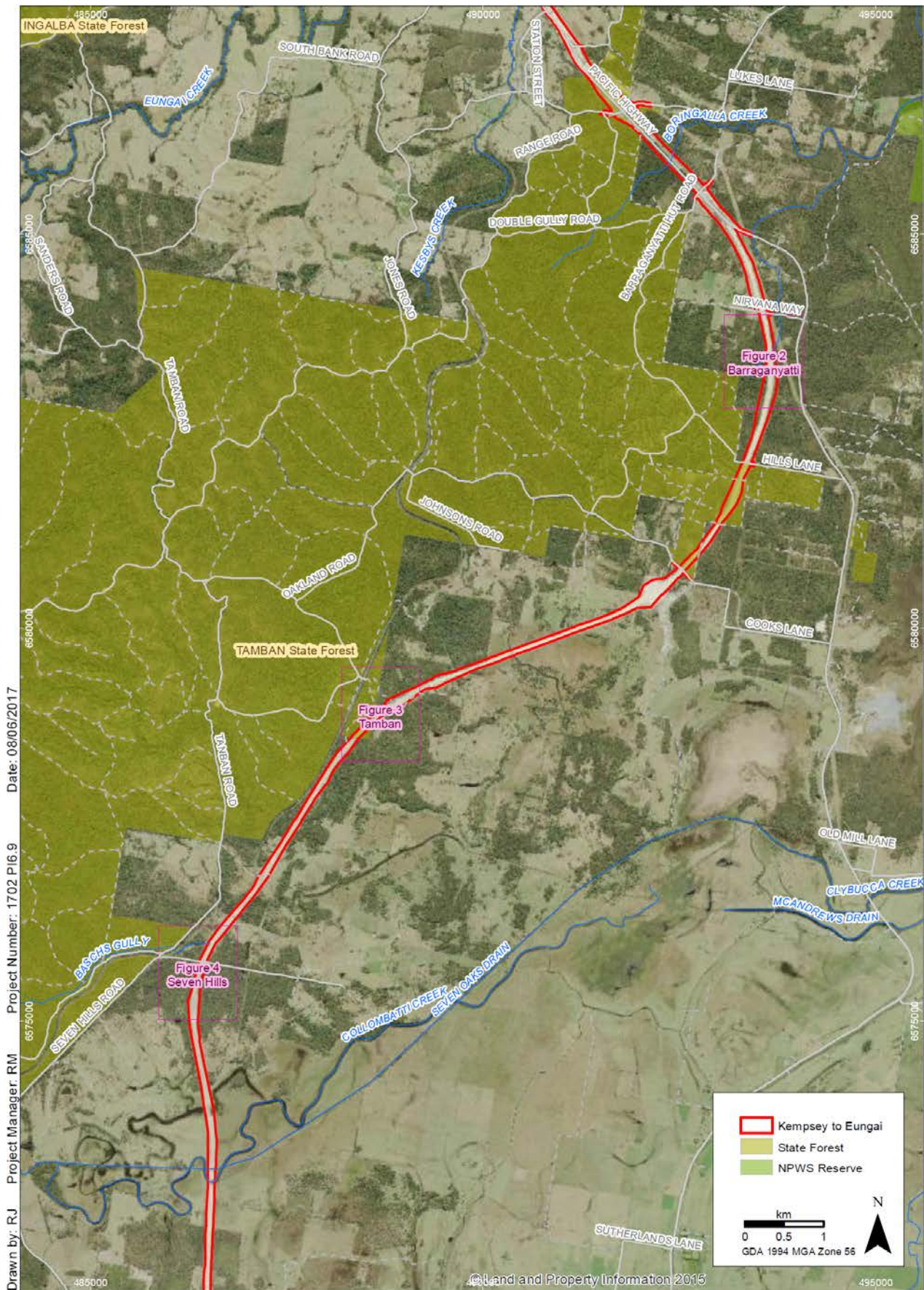
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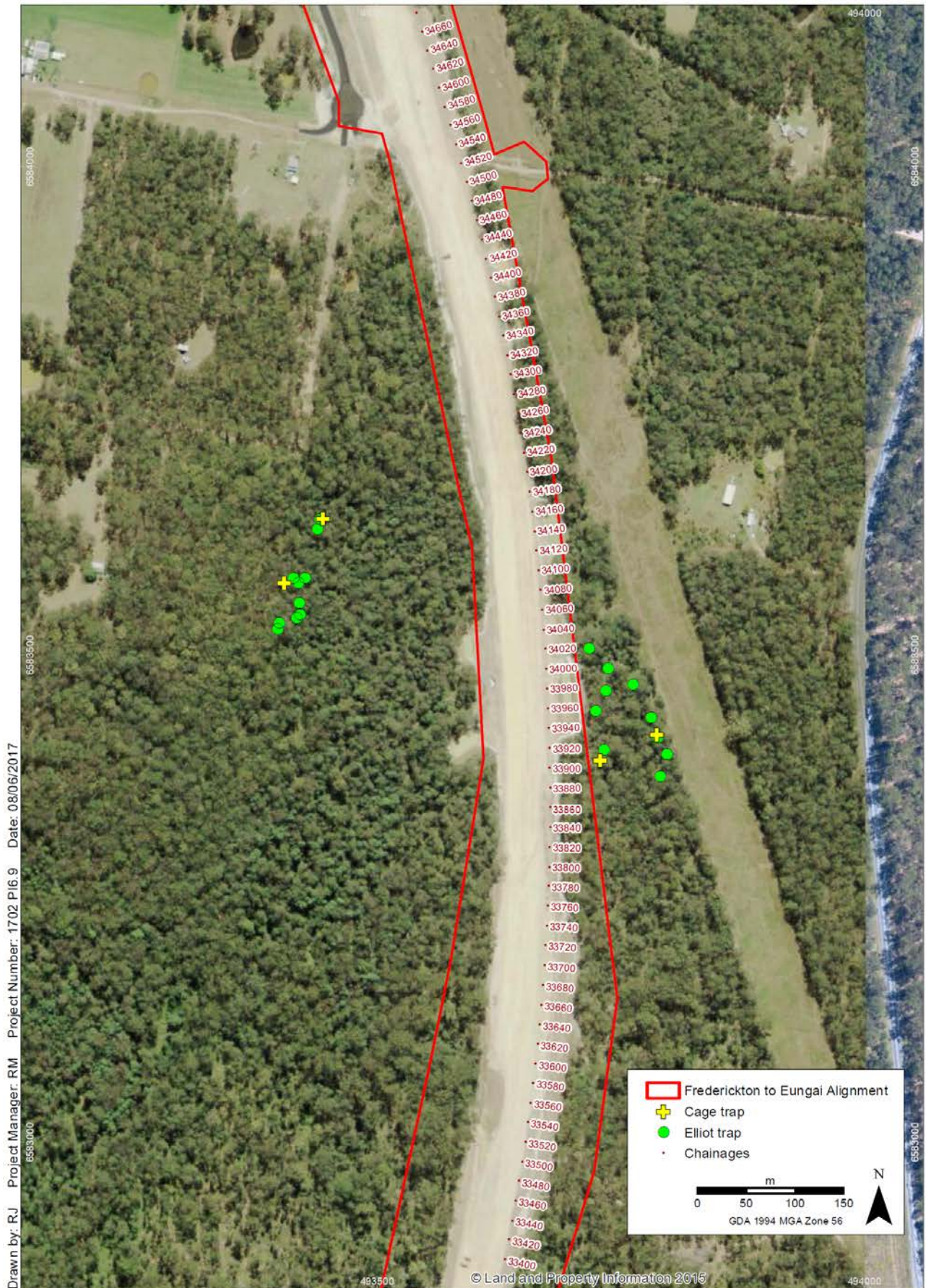
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Scarff, F.R., Rhind, S.G. and Bradley, J.S. (1998). Diet and foraging behaviour of brush-tailed phascogales (*Phascogale tapoatafa*) in the jarrah forest of south-western Australia. *Wildlife Research* 25: 511–526.

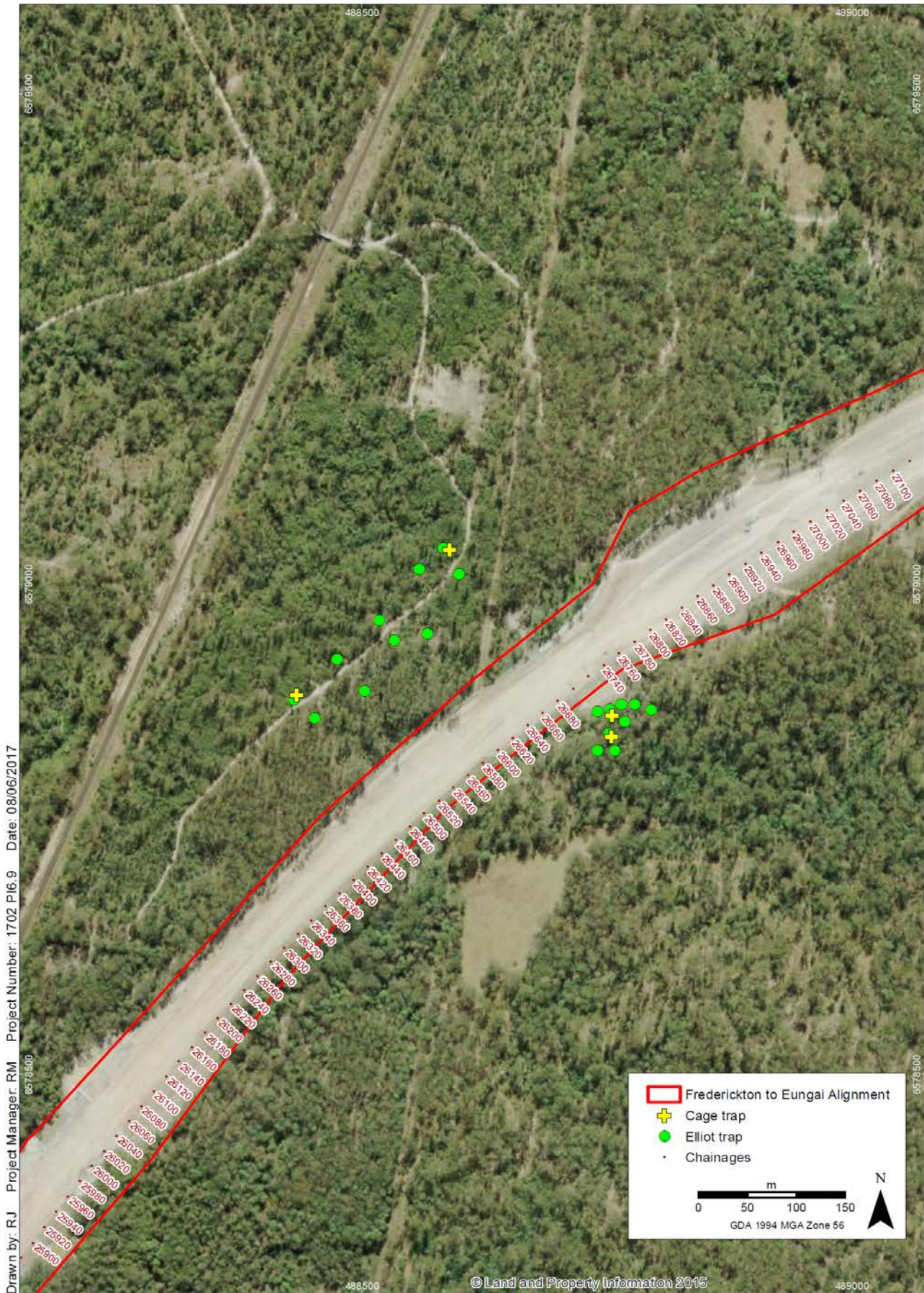


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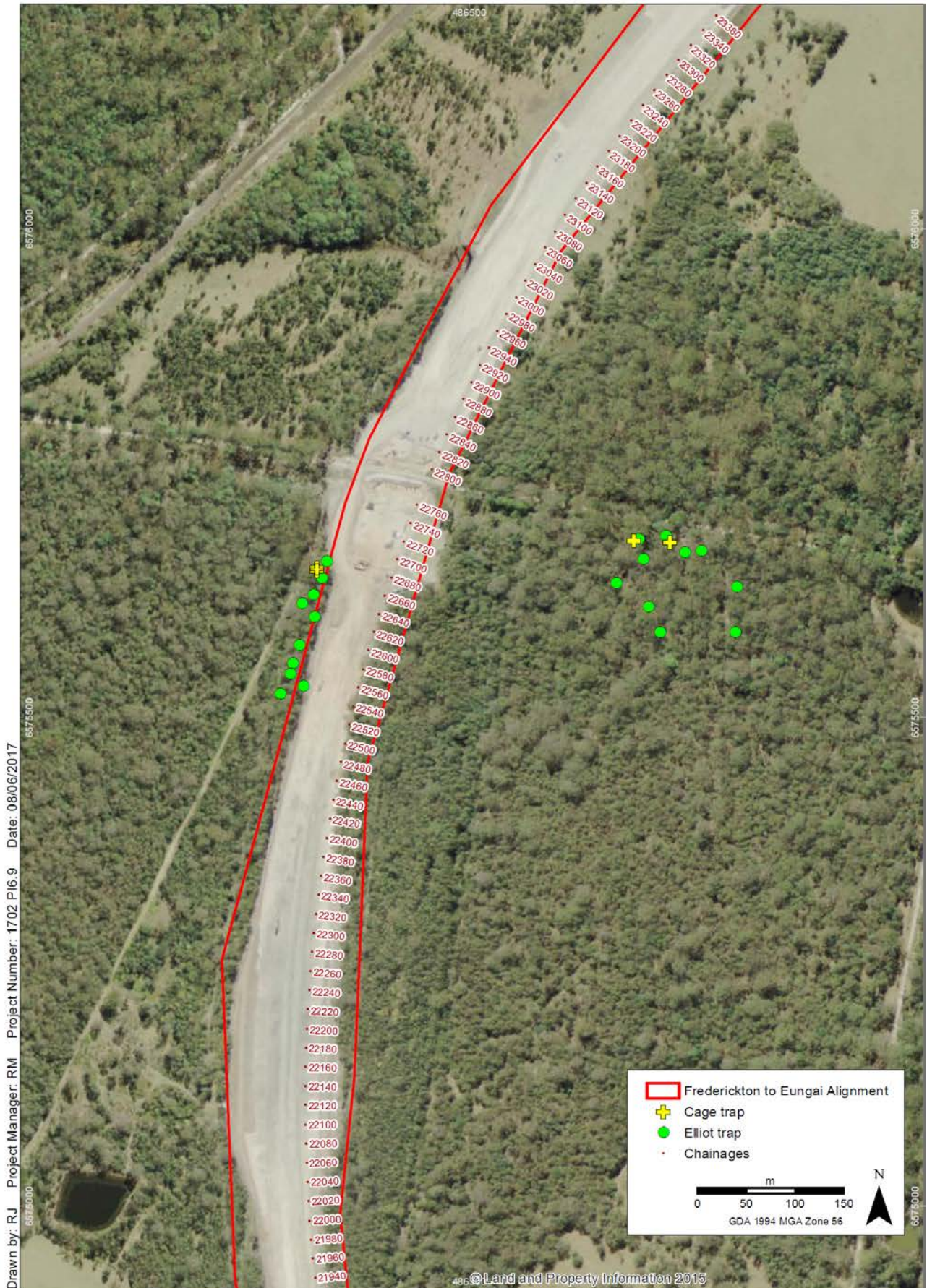
Brush-tailed Phascogale Monitoring Sites: Overview
Pacific Highway Upgrade - Fredericton to Eungai



Brush-tailed Phascogale Monitoring Sites: Barraganyatti
Pacific Highway Upgrade - Frederickton to Eungai



Brush-tailed Phascogale Monitoring Sites: Tamban
Pacific Highway Upgrade - Frederickton to Eungai



Brush-tailed Phascogale Monitoring Sites: Seven Hills
Pacific Highway Upgrade - Frederickton to Eungai

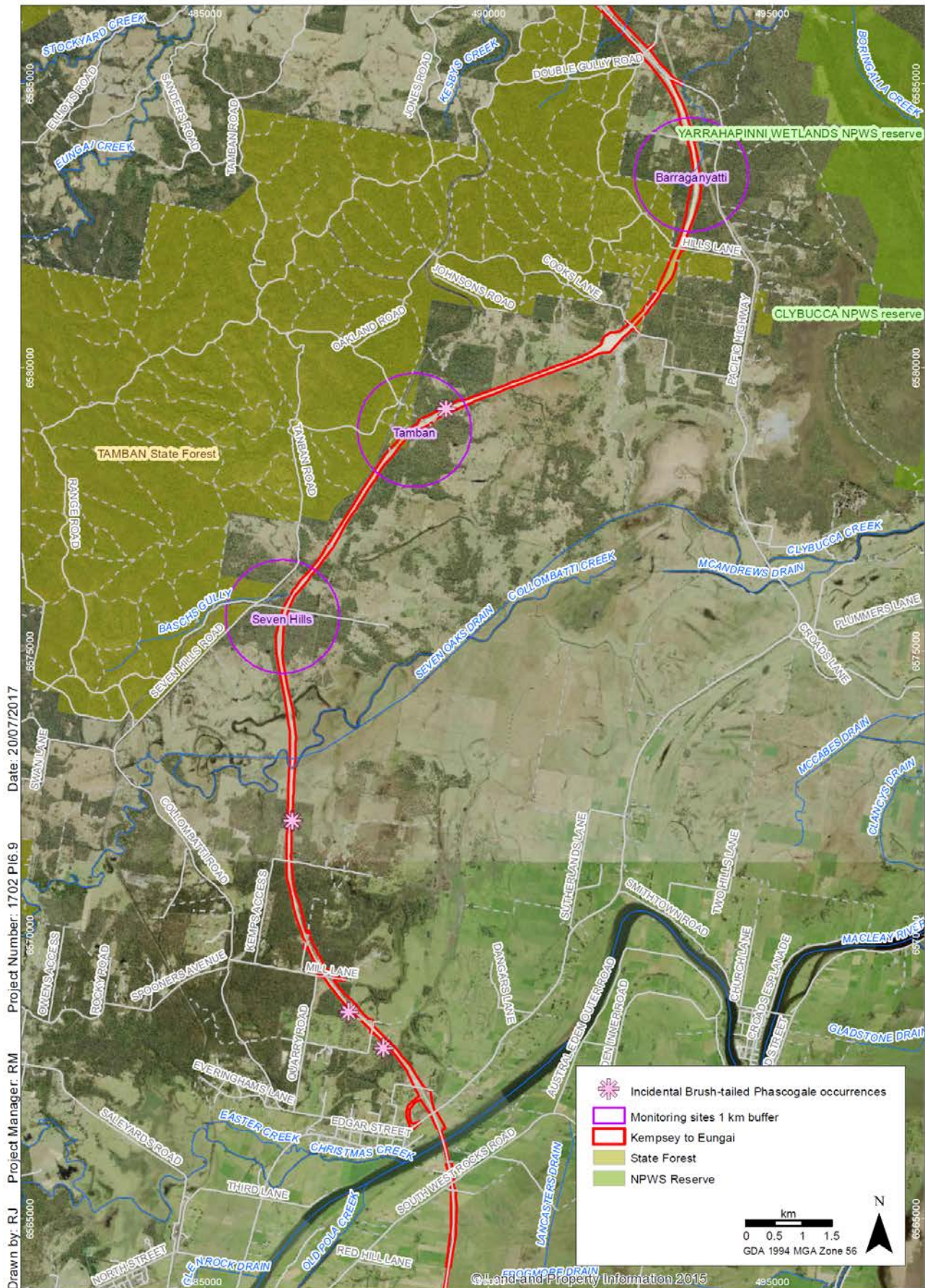


Figure 5: Brush-tailed Phascogale additional observations
Pacific Highway Upgrade - Fredericton to Eungai

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